



East Fork Lewis River Ridgefield Pits Restoration

Basis of Design Report – Final Design

Lower Columbia Estuary Partnership & Inter-Fluve

June 2024

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Attachments

- Attachment 1: Subsurface Investigations Tech Memo (IFI, February 2024)
- Attachment 2: Geotechnical Investigations Report (GRI, March 2024)
- Attachment 3: Topobathymetric LiDAR Report (NV5, April 2023)
- Attachment 4: Wetlands Report (LCEP, 2023)
- Attachment 5: Geomorphology Report (IFI, Jan 2020)
- Attachment 6: Sediment sampling data (LCEP and IFI, 2020)
- Attachment 7: Ridgefield Pits Alternatives Analysis Report (LCEP and IFI, July 2020)
- Attachment 8: Hydraulic modeling figures (IFI, May 2023)
- Attachment 9: Water Temperature Analysis (LCEP, Oct 2021)
- Attachment 10: Soil Quality Sampling technical memo (FS, Aug 2023)
- Attachment 11: Erosion Risk Assessment (IFI, April 2024)
- Attachment 12: Dyer Creek Project Area – Design Report (IFI and LCEP, April 2024)
- Attachment 13: Large Wood Stability Evaluation (IFI, April 2024)

1. Introduction

1.1. Overview

This report describes the Lower East Fork Lewis River Ridgefield Pits project, including background information, site conditions, site investigations that have been performed as part of design, and the proposed design components at the final design level (revised from the 60% design). The project area covers the Ridgefield Pits reach and adjacent upstream and downstream areas on the lower East Fork Lewis River (EF Lewis River). The project aims to restore habitat conditions for ESA-listed salmonids, including winter and summer steelhead, fall Chinook salmon, coho salmon, and chum salmon. The project will restore instream habitat, riparian habitat, and floodplain processes in a section of river that has been heavily impacted by past floodplain gravel mining, gravel mining capture (avulsion into floodplain gravel pits), floodplain fill, levees, bank armoring, tributary culverts, riparian clearing, and a host of past and ongoing land uses that have encroached on the historical floodplain and channel migration zone.

1.2. Project Summary

The lower East Fork of the Lewis River provides important aquatic habitats and ecological functions. The EF Lewis is one of the largest undammed rivers in the Lower Columbia and it provides a key role for recovery of ESA-listed salmon and steelhead in the region. Five populations of ESA-listed salmon utilize the EF Lewis, including coho, fall Chinook salmon, winter steelhead, summer steelhead, and chum (albeit in very small numbers). All five of these populations are listed as “Primary” populations in the Lower Columbia Salmon and Steelhead Recovery Plan (LCFRB 2010), meaning they are critically important for recovery at the regional “Evolutionarily Significant Unit” (ESU) scale, for these species. Furthermore, the reaches that are the focus of restoration in this project (EF Lewis 5A, 5B, 6A, 6B, 6C, 7, and 8A) are all listed as Tier 1 reaches in the Recovery Plan (and annual Habitat Strategy), with a high value for restoration, meaning that they are some of the most important reaches to focus restoration work within this high priority subbasin.

The project reaches have been heavily impacted by past and on-going land uses since at least the late 1800s. This includes early clearing for agricultural use, instream and floodplain gravel mining, residential development, roads and bridges, bank armoring, levees and fill for flood protection, instream wood removal, and riparian clearing. In particular, gravel mining has had a significant and lasting impact on habitat conditions in the lower EF Lewis River. The historical aerial photo record shows that instream and stream-adjacent gravel mining occurred at least as early as the 1930s, occurred in several places within the project area up until the 1990s, and is still occurring today at the Daybreak Mine in the historical floodplain to the north of the project area. The core focus area of this project, the Ridgefield Pits, were mined for gravel starting in the 1950s. In 1996, the mainstem river avulsed into the pits (gravel pit capture), abandoning 4,000 feet of former high quality salmon spawning and rearing habitat and replacing it with deep pits with poor habitat quality dominated by invasive and predatory species. More information on the land use history and resulting channel and habitat changes are included in the Geomorphology Report (Attachment 5).

As a result of the Ridgefield Pits avulsion and other land-use impacts, current habitat conditions are impaired throughout the project area. A 2005 habitat survey (SP Cramer & Associates) for reaches 5-8A

revealed ‘not properly functioning’ conditions for pool frequency, ‘at risk’ conditions for pool quality, and ‘not properly functioning’ conditions for large woody debris frequency. The Ridgefield Pits reach (6A) was shown to be particularly impaired with respect to morphologic complexity, vegetation, shade, and substrate conditions. In this reach, the former pool-riffle channel (pre-avulsion) was converted to a series of deep slow-moving pools that lack suitable spawning, rearing, and migration habitat for salmonids. Summertime water temperatures have also been shown to exceed standards within the pits and throughout the project area. Sampling in 2005-6 by the Washington State Department of Ecology showed numerous violations of the state standard of 16°C for the 7DADMax (7-day average of the daily maximums) at sites within the project area, including values above 23°C (WA Dept of Ecology 2021). Unpublished data collected from 2010-2020 by other entities (Estuary Partnership, Fish First and WDFW) confirm that temperatures exceed the water quality standard regularly. These conditions are problematic for native fish and also create conditions that favor invasive predatory species.

Planned restoration treatments span the nearly 3-mile project area and include both instream and floodplain actions. The core Ridgefield Pits area will include a complete re-grading of nearly 70 acres to create a multi-thread channel network that is highly connected to the floodplain and with multiple alcoves, off-channel areas, and floodplain wetlands. New side-channel, alcove, and floodplain wetland habitats will be created in upstream and downstream areas. Numerous levees, floodplain fill, and some sections of bank armoring will be removed to restore floodplain connections, channel migration processes, and to create new off-channel and wetland habitats. Material sourced from excavation areas will be used as part of the re-grading for the core Ridgefield Pits reach. Large wood habitat will be placed throughout newly-created and existing habitats to enhance complexity and cover and to restore natural channel dynamics. Native riparian and floodplain vegetation will be planted in numerous locations to support long-term ecological function. These treatments are expected to improve the recovery of key geomorphic functions and habitat throughout the project area, with significant increases of high quality fish habitat and improvements to fish productivity.

1.3. Background

This project is led by the Lower Columbia Estuary Partnership (Estuary Partnership). Project planning and design has been performed by the Estuary Partnership and a consultant team led by Inter-Fluve. The project has received input from a multi-stakeholder Technical Oversight Group (TOG) facilitated by the Estuary Partnership. The TOG is comprised of technical representatives from interested and involved stakeholders and resource agencies.

Preliminary project planning and design was funded through a grant from Washington State Salmon Recovery Funding Board (Washington Recreation and Conservation Office, RCO) Project #17-1070. Final design has been funded, in part, by RCO project #21-1127. Other funding sources to support additional design and construction have also been secured.

Preliminary designs were completed in June 2021. The design approach was informed by an alternatives analysis performed with input and guidance from the TOG (see Section 4 for a summary and Attachment 7 for the alternatives analysis report). A draft 60% design was completed in June 2023 and a revised draft 60% in November 2023. This final design represents the continued development of the preferred approach. In addition, interrelated elements have been modified, removed, or added to the current designs. This includes the following changes from the 2021 Preliminary Design:

- 1) Removal of the Mill-Manley restoration elements, River Mile (RM) 9.3 – 9.6.
- 2) Addition of actions at the “Daybreak Trial” site, RM 9.6 – 9.9
- 3) Addition of actions at the “County Yard” site, adjacent to the upper side-channel treatments in the preliminary design, RM 9.2 – 9.6
- 4) Addition of actions at the Danger Park site, RM 9 – 9.1
- 5) Addition of actions at the “East Floodplain” site, adjacent to the lower side-channel treatments in the preliminary design, RM 8.1 – 9.0
- 6) Addition of actions at the “West Floodplain” site (aka Powerline Bend Side-Channel), RM 7.0 – 7.25. *Note that a longer side-channel complex through the west floodplain that went through the BPA powerline right-of-way and that was included in the 60% design has been removed and a new shorter side-channel at “Powerline Bend” (near RM 7.2) has been added.
- 7) Incorporation of the Dyer Creek Project area elements, RM 6.6 to 7.0

The Dyer Creek Project, located at the downstream end of the project area, was previously brought to the Preliminary Design level as part of a separate project, but has now been incorporated into the final designs for the greater Ridgefield Pits Project. Because of the separate survey and analysis that occurred as part of the preliminary design, and because of separate grant funding (RCO #20-1065 and #22-1214), most of the information related to the Dyer Creek Project is included in a separate design report specific to the Dyer Creek Project area (Attachment 12). The exceptions are the hydrologic and hydraulics analyses, which were performed for the entire project reach including the Dyer Creek area for the final design phase and are described in this report.

The suite of proposed restoration actions are summarized below in Section 2.1, with greater detail provided in Section 5.

1.4. Supporting Studies

There has been considerable past analysis of the lower EF Lewis River and restoration planning for the project area. The following previous studies have evaluated habitat, land use impacts, and/or restoration opportunities in the study area and have been reviewed as part of this effort.

- Daybreak Mine Expansion Habitat Conservation Plan (HCP) (Storedahl & Sons 2003). Includes the main HCP document as well as the following attachments or follow-up work that are relevant to this effort:
 - Conceptual Restoration Plan for Ridgefield Pits (R2 Resource Consultants 1999) – Appendix B of the HCP
 - Geomorphic Analysis of the East Fork Lewis River (WEST Consultants 2001) –Appendix C of HCP
 - Daybreak Ponds Avulsion Mitigation (WEST Consultants 2001 and Ecological Land Services) – Addendum 1 to Appendix C of HCP
 - Conservation Measure (CM)-09 Avulsion Contingency Plan
 - Conservation Measure (CM)-10 Requirement for a “Study of the Ridgefield Pits and East Fork Lewis River”
 - Monitoring and Evaluation Measure (MEM)-07 Requirement for “East Fork Lewis Channel Bank Stability Monitoring”
- Assessment and Strategic Plan for East Fork Lewis River (Dover Habitat Restoration for Friends

of the East Fork 2003)

- East Fork Lewis River (RM 13 to RM 6), Including West Daybreak Park Project Reach – Fluvial Geomorphology and Erosion and Sediment Evaluation (Frank Reckendorf 2010).
- The Lower East Fork Lewis River Subbasin: A Summary of Habitat Conditions, Salmonid Distribution, and Smolt Production (WDFW 2001)
- East Fork Lewis River Basin – Habitat Assessment (SP Cramer & Associates 2005)
- Lower East Fork Lewis River Habitat Restoration Plan (Inter-Fluve and Cramer Fish Sciences, for LCFRB 2009). This effort identified the need for restoration of the pits reach and provided a coarse-scale description of opportunities and potential costs.
- Quality Assurance Project Plan East Fork Lewis River Temperature and Fecal Coliform Bacteria Total Maximum Daily Load Study (WA Department of Ecology, Publication 05-03-110, 2005).
- East Fork Lewis River Alternative Restoration Plan – A strategy to achieve bacteria and temperature water quality standards (WA Department of Ecology, Publication 21-10-051, October 2021).

1.5. Project Goals

Project goals were established through the workgroup (TOG) process described above and are listed below. The project objectives and design criteria that fit within these goals are included in Section 4.1. These goals were originally developed as part of the Preliminary Design phase.

- Goal 1. Restore native vegetation communities: Restore a patchwork mosaic of age classes and native species that dominate riparian and floodplain areas, with vegetation supported by channel migration processes and high seasonal water table.
- Goal 2. Enhance thermal refuge and incorporate cold water areas into restoration efforts: Protect and enhance existing cold water areas in order to decrease thermal loading to the mainstem and provide thermal refuge to benefit pre-spawn holding and spawning for coho, Chinook, steelhead and chum and summer juvenile rearing habitat for coho, Chinook and steelhead. Improve habitat quantity and quality in the existing thermal refuge areas. Assess potential to leave pits that contain cooler water as refuge areas during the design and construction phases of the project.
- Goal 3. Increase the quality and quantity of Chinook, chum, steelhead and coho spawning and rearing habitat: Create habitat conditions that are consistent with the geomorphic setting. Restore a complex, multi-thread channel network that includes greater channel planform complexity, pools with instream cover, riffles for macroinvertebrate production, and tail-outs with abundant spawning gravel. Increase floodplain habitat availability and complexity in the form of abandoned oxbows, floodplain wetlands, secondary and side- channel connectivity, and beaver dam complexes that are accessible to fish at a range of flows.
- Goal 4. Restore Channel Migration Zone and Floodplain Connectivity: Restore portions of the historical channel migration zone and restore natural rates of floodplain inundation, where possible, by 1) removing hydromodifications; and 2) achieving channel and floodplain geometry and elevation that encourage frequent overbank flows and natural rates of channel adjustment.
- Goal 5. Create a dynamic channel that allows for natural rates of channel adjustment and sediment transport: Allow for natural rates of channel adjustment in concert with sediment supply

and hydrology regime. Maintain depositional conditions, especially within the pits to promote sediment capture and to re-build the grade lost to avulsion, and to restore sediment transport processes into and through the area.

- Goal 6. Develop restoration approaches and actions that are consistent with existing land use:
Avoid increase of flood or erosion risk to public or private infrastructure. Take into consideration the potential for a future avulsion of the EFLR into the Daybreak Pits. Consider the implications of designs for recreation users along the river.

2. Site Conditions

2.1. Site Overview

The project area extends from approximately river mile (RM) 6.6 (downstream of the Ridgefield Pits) to RM 10 (downstream of Daybreak Bridge) and comprises multiple related sites and proposed restoration features. An overview map of the project area showing the various project sites and elements is shown in Figure 1. The project area includes the following sites or “action areas”:

- 1) Ridgefield Pits – this is the core avulsion area that will be re-graded into a multi-threaded system highly connected to the floodplain and with multiple alcoves, off-channel areas, floodplain wetlands, and abundant large wood habitat.
- 2) West Floodplain – this is downstream of the Ridgefield Pits and includes the construction of a new side-channel at Powerline Bend near RM 7.2.
- 3) East Floodplain – this is upstream of the Ridgefield Pits and includes construction of two new side-channels, one connector side-channel, backwater alcoves, selective floodplain lowering to obtain coarse-grained material, and enhancement of an existing side-channel.
- 4) Danger Park – This area includes the County’s “Danger Park”, accessed off of NE Bennett Road, as well as an adjoining parcel owned by Columbia Land Trust. The Danger Park pit, a former County gravel mining pit, will be filled as part of the project.
- 5) County Yard – this is the area in and around Clark County’s Daybreak Maintenance Yard. It will include relocation of the gravel sorting yard, fill removal, levee removal, and creation of floodplain wetlands.
- 6) Daybreak Trail – this area has also been called “Lower Daybreak” in the past and is the location of an existing paved trail along the river that connects to Daybreak Park upstream. This area will include floodplain lowering, bank sloping, channel margin habitat improvements, and extensive riparian and floodplain revegetation.
- 7) Dyer Creek – this project area, which was brought to the Preliminary Design level as part of a separate project, is incorporated into the final design for the greater Ridgefield Pits Project. It includes riprap removal on two banks, enhancement/reconnection of the Dyer Creek tributary to the mainstem EF Lewis, fish passage improvements (culvert removals and replacements) on lower Dyer Creek, and large wood placements in the mainstem EF Lewis and lower Dyer Creek.

A primary focus of the project is the Ridgefield Pits avulsion area. This is the location of the main channel avulsion (gravel pit capture) into the Ridgefield Pits gravel mining pits, which occurred in the

mid-1990s. The pits include nine former gravel mining pits between RM 7.5 and RM 8 (Figure 2). The avulsion caused the abandonment of approximately 4,000 feet of former stream channel and the river now flows through the former gravel mining pits/ponds. At the upstream end, a new delta formed of deposited riverbed material has developed since the avulsion (Figure 2).

In the valley bottom and former floodplain to the north and east of the Ridgefield Pits are the gravel pits of the Daybreak Mine, some of which are still being actively mined. The processing area for the Daybreak Pits is located immediately adjacent to the Ridgefield Pits north of RM 8. The processing area is accessed from the east via NE Storedahl Pit Road, which abuts the project area along the river-right side. The road separates the river and floodplain from the Daybreak Pits mining area. Just upstream, in the floodplain north of RM 9, is Danger Park, an undeveloped County Park consisting of two former gravel pits. Upstream of this, north of RM 9.5, is the Clark County maintenance yard (“Daybreak Maintenance Site”), consisting of a County maintenance shop and office and a sand and gravel storage and sorting yard. There is an associated levee and bank armoring to the south and west of the yard. At the upstream end of the project area, from approximately RM 9.5 to 9.9 on river-left (south of the river), is the County’s Lower Daybreak property. The tributaries of Mill and Manley Creek enter the river just downstream of this site. A house, now owned by the County, is located at RM 9.5. The County has long-term plans to remove this house. Upstream is a long actively-eroding cut bank with a paved trail near the top of the bank and a large grass field extending upvalley to the east to the Daybreak Park boat ramp and NE 82nd Avenue. NE 82nd Avenue crosses the EF Lewis at Daybreak Bridge, just upstream of the project area at RM 10.2.

Near the downstream end of the project area, at RM 7.3, Bonneville Power Administration (BPA) transmission lines cross the river and valley bottom, with 3 powerline towers located along the river-left (west) margin of the Ridgefield Pits. Another powerline tower is located to the north of the river near RM 7.2 at ‘Powerline Bend’. This bend has been actively migrating to the north and has been the site of multiple past bank treatments to control erosion. Downstream of the powerlines, near RM 6.9, the tributary Dyer Creek enters the river from the south. Dyer Creek enters the valley bottom from the south, just west of the BPA powerlines and follows an old mainstem EF Lewis channel scar, flowing through wetlands and an abandoned oxbow pond before entering the mainstem. Just downstream of the Dyer Creek confluence are two sections of riprap bank on river-left, with a water withdrawal (pump station) located in a small alcove between the two riprap banks. These elements (lower Dyer Creek, riprap banks) comprise the Dyer Creek project area.

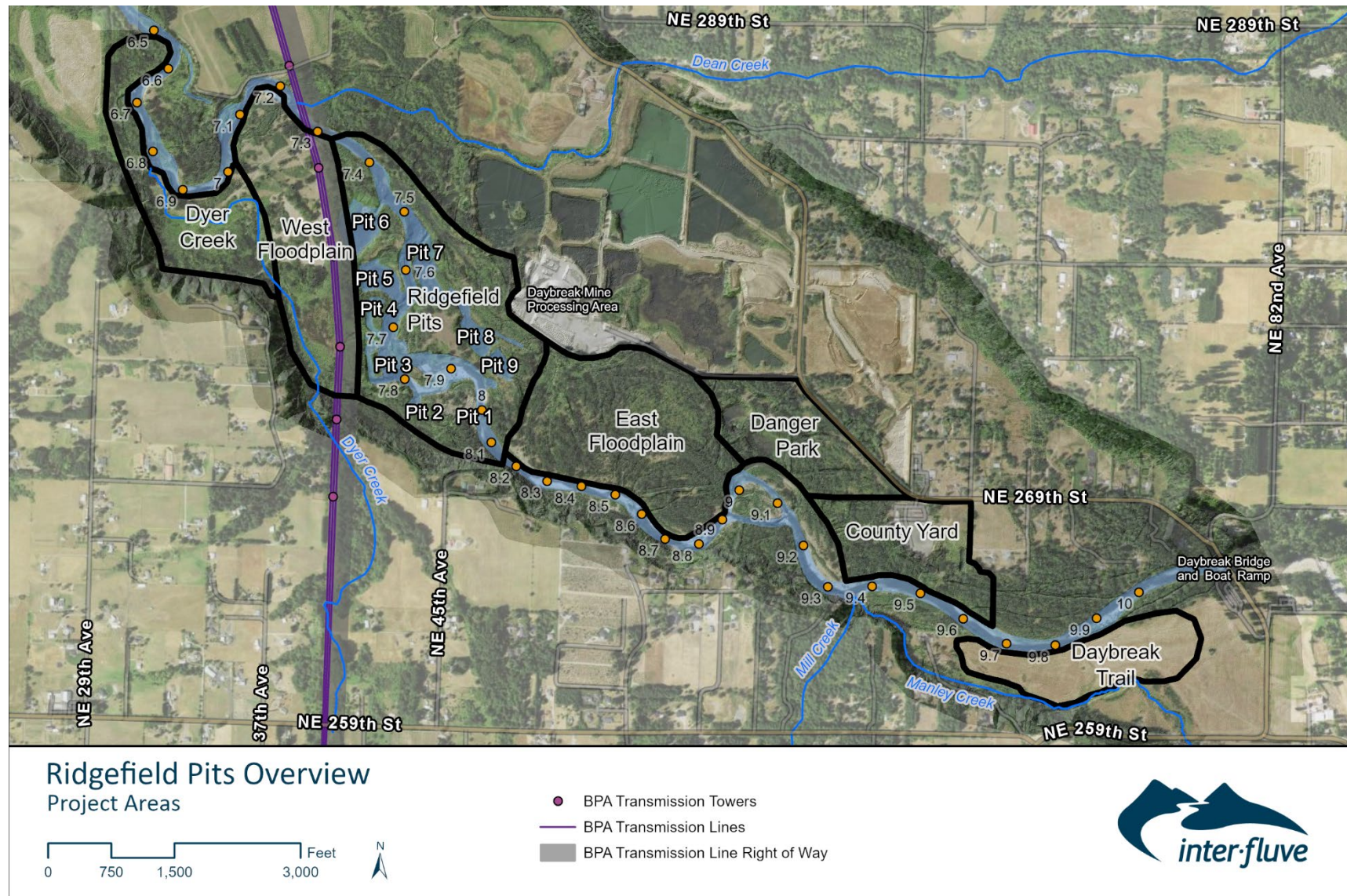


Figure 1. Project area overview

Overview map of project area showing the individual action area locations.



Figure 2. Oblique aerial view of Ridgefield Pits.

There are nine pits total. Several of the pits have filled considerably with sediment while the majority have filled very little over the last 27 years. The delta forming at pits 1 and 2 has led to increased habitat complexity. This location has shown some of the highest juvenile fish counts. Flow is towards the top of the image. This oblique aerial was shot during a helicopter tour June 12, 2019.

2.2. Landownership

Landownership of the project area is a combination of private lands, County lands, conservation lands, and state lands (Figure 3). The Ridgefield Pits themselves are owned by CEMEX (formally Pacific Rock Products) Environmental Enhancement Group, which is a conservation entity set up to hold the lands in conservation use following the cessation of mining by Pacific Rock Products in the 1990s. The majority of the adjoining floodplain lands upstream and downstream are owned by Clark County, with some instances of private ownership, including one parcel owned by Columbia Land Trust. The river channel itself within the Ordinary High Water line is State-Owned Aquatic Land, managed by the Washington Department of Natural Resources.

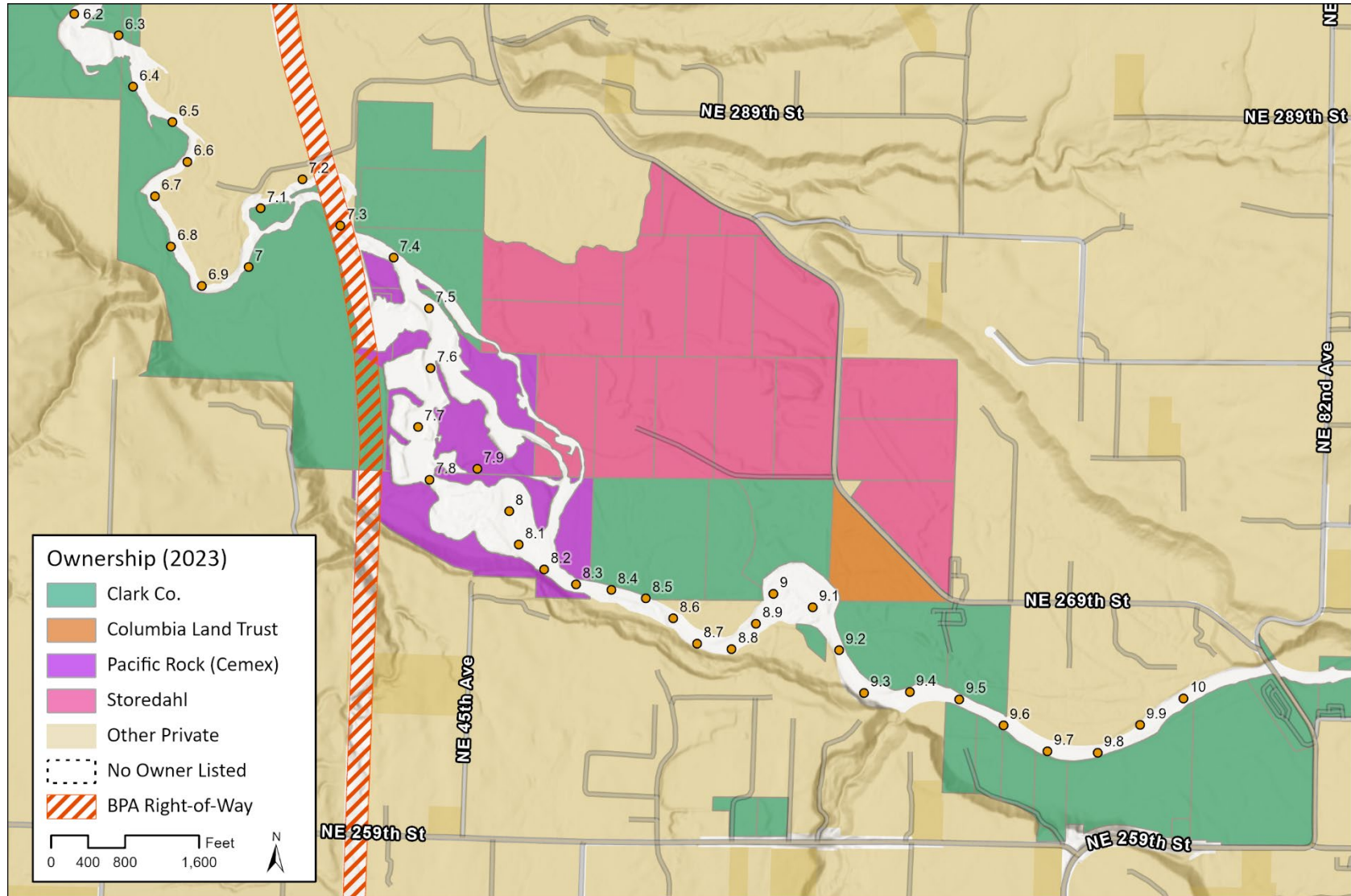


Figure 3. Land ownership.

Data obtained from Clark County 2023. Non-colored areas do not have an owner listed and were river corridor or connected water body areas at the time of mapping. These areas are assumed to roughly approximate State-Owned Aquatic Lands.

2.3. Geology and Geomorphic Setting

A geomorphic investigation was performed and describes the geomorphic setting, the influence of human actions on geomorphic processes, and anticipated future trends. The geomorphic report is included as Attachment 5. A brief summary of the geomorphic setting is included here.

The headwaters of the EF Lewis River originate in the foothills of the Cascades at an elevation of approximately 4,100 ft. The river flows east to west, entering the lower North Fork Lewis River at sea level. The project site is located just above tidal influence, which extend up to approximately Mason Creek at RM 5.7, which is 1.3 miles downstream of the project area. Within the project area, the river flows through a wide (0.5 - 0.9 mile), unconfined valley with a very low gradient (<0.004 ft/ft). The entire river valley is composed of young (Holocene) alluvial sediments (fines to cobbles; see Section 3.2 for more substrate information). The modern river is confined to a narrower floodplain and channel migration corridor due to valley bottom development, fill, roadways, and mining. The river through the project area abuts the high valley wall on river-left in a few locations, causing erosion of the high walls, which are composed of various layers of highly erodible material including fines, gravels, and cobbles.

US Government land office maps from the 1850s indicate that the entire valley bottom was historically well-connected to the hydrology of the river. The valley bottom was labeled as a “low rich bottom subject to inundation” and was illustrated as an extensive wetland area. The river in the vicinity of the Ridgefield Pits was mapped as a multi-threaded channel, with as many as 6 or more interconnected channel threads (Figure 4). Upstream and downstream areas were drawn as highly sinuous with occasional secondary channels. This information suggests that the river through the Ridgefield Pits reach was historically anabranching, characterized by multiple channel threads separated by vegetated islands. Historical presence of this channel type is further supported by a regional (Columbia River Basin) channel typing analysis conducted by Beechie and Imaki (2014), whose model predicts an anabranching channel type throughout the study area. It is very possible that upstream and downstream areas may have more likely been highly sinuous meandering or would have alternated periodically between these two channel types. Early maps (1850s GLO maps) and photos (1939) suggest that, historically, there was abundant side-channel habitat. There was also abundant instream large wood, likely creating stable jams and forested island features. The large wood in the channel, and large and robust riparian and floodplain vegetation, likely resulted in relative stability of the channel during regularly recurring floods (i.e. annual to 5-year event); with channel adjustments via scrolling and avulsions occurring during the larger, less common events ($> \sim 5$ -year event). These disturbance events would create a complex patchwork mosaic of instream and floodplain aquatic habitats, with high productivity of fish and other aquatic species in the intervening years.

An aerial photo analysis was performed as part of the geomorphology evaluation, and the imagery, along with a detailed chronology of changes, can be seen in the report (Attachment 5). The analysis shows that impacts to the valley bottom were already well underway prior to the first aerial photos in 1939. The 1939 aeriels show farms and residences throughout the valley bottom, although the valley bottom, including in the project area, was considerably more vegetated than today. Various episodes of instream and floodplain gravel mining can be seen throughout the lower river in the aerial photos, with mining occurring at least as early as the 1930s and continuing today. With the progression of time and increasing human impacts, the river gradually became more single-threaded, more incised, less complex, and less connected to its floodplain and channel migration zone. Aquatic habitat has suffered

accordingly. The exceptions to this are a few areas where recent channel changes have created greater complexity in channel form, greater habitat diversity, higher wood abundance, new side-channel formation, and new growth of native riparian vegetation. An example is the actively scrolling meander near RM 9. However, the rate of adjustment of these areas, which occurs every one to three years, may be too frequent. This is likely the result of a lack of large key instream wood pieces and young riparian forest structure, as well as disrupted reach-scale sediment transport and deposition processes. Although these highly dynamic areas exhibit greater habitat complexity, the rate of change may be more frequent than historical conditions and may result in less-than-ideal conditions for spawning and early salmonid rearing due to scour and deposition within spawning areas.



Figure 4. 1854 GLO Map.

In this image, the 1854 GLO map is overlaid on a modern aerial photo. The map shows an anabranching channel planform in Ridgefield Pits area prior to Euro-American settlement. The channel was highly connected to the adjacent floodplain. Flow is from bottom right to top left. The Ridgefield Pits are outlined for reference. The Daybreak Pits lie to the right of the Ridgefield Pits.

2.1. Ridgefield Pits Avulsion and Subsequent Channel Changes

The avulsion of the East Fork Lewis River into the Ridgefield Pits in the 1990s has had a major influence on river processes and is the primary reason for pursuing restoration actions. Prior to the avulsion, the pits were located in the floodplain to the west and south of the river, separated by low berms from the river channel. By the 1990s, mining had been completed. Full avulsion and pit capture occurred in

November 1996. Prior to this, a lateral breach had occurred into the northeast corner of the pits (Pits 7 and 8). This occurred as early as 1990 and the breach was exacerbated during the February 1996 flood event. This breach resulting in partial filling of pits 7 and 8. The 1996 avulsion essentially captured and re-routed the entire river, routing flow and sediment into and across the former mining pits (Figure 5). The avulsion resulted in the abandonment of approximately 4,000 linear-feet of the former river channel. To date, the river continues to flow through the remains of the former gravel mining pits. This condition has resulted in substantial habitat loss and habitat degradation, in particular, for salmonids.

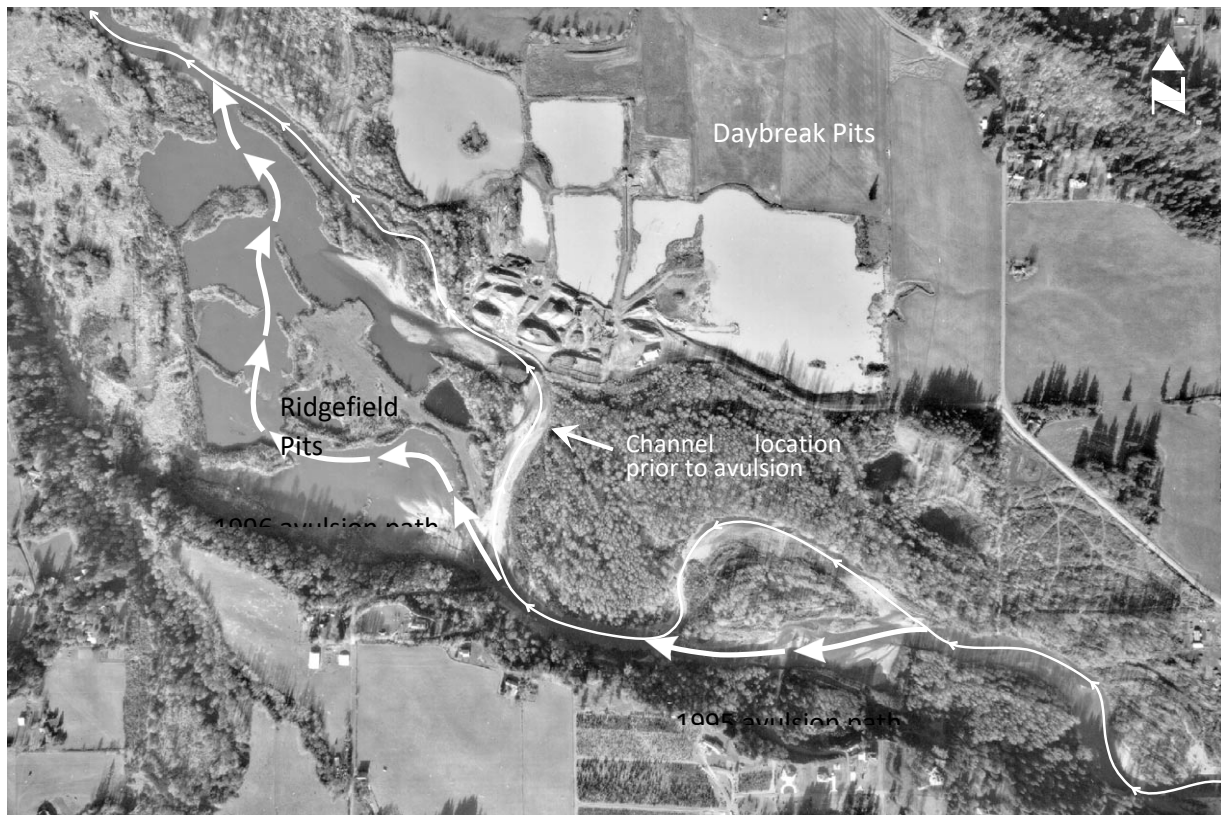


Figure 5. Ridgefield Pits avulsion.

Reproduced from Norman et al. (Washington DNR 1998). Flow is from right to left.

The Geomorphology Report (Attachment 5) includes detailed information on the avulsion and resulting channel and habitat changes. A summary of the key points, repeated here from the alternatives analysis (Attachment 7) is provided below.

- Upstream migration of the head-cut that developed in response to the 1996 Ridgefield Pits avulsion (described by Norman et al. 1998, and multiple reports associated with the Storedahl Daybreak Mine HCP 2003) appears to have ceased and the river profile has largely stabilized throughout the project area upstream of the pits, according to 2019 updated bathymetric profiles.
- Active channel dynamics upstream of Daybreak Bridge (and upstream of the project area) are within the range of historical conditions and do not appear to pose a significant risk to downstream project work (Inter-Fluve 2020). It has been noted in discussions with the technical

oversight group, however, that risk of avulsion in this reach is present, and sediment transport processes have been impaired.

- Trapping of sediment in the Ridgefield Pits has likely reduced sediment transport to downstream reaches, including spawning gravels.
- Ridgefield Pits 1 and 2 have experienced significant sediment infilling and wood accumulation, much of which occurred within 10 years of the 1996 avulsion. This has resulted in improved habitat diversity, fish use, hyporheic exchange, and channel processes in this area.
- Despite the significant infilling of Ridgefield Pits 1 and 2 that has occurred, the analysis of infilling rates since the 1996 avulsion indicates that overall infilling of the Ridgefield Pits will likely not occur for at least another 50–60 years (2070, minimum). This is considerably slower than prior estimates, which predicted recovery by approximately 2026. The analysis shows a substantial slowdown in overall filling subsequent to the decade following the avulsion (Inter-Fluve 2020). As a result, mainstem habitat below Pits 1 and 2 has remained in a very low-quality state since 1996, characterized by deep, warm pools, slow flow and abundant predatory fish (Estuary Partnership snorkel survey, 2018).
- Ridgefield Pits 8 and 9, which are located off the mainstem EFLR, are subject to groundwater inflows and thus may be providing some thermal refuge for juvenile salmon during summer months. Pit 9 is likely to only be accessible to fish during very high flood flows.

2.1. Vegetation

Valley bottom vegetation consists of a complex mosaic of aquatic, wetland, riparian, and upland species. Most of the valley bottom where active riverine processes (flood inundation, channel migration) are still intact contain native species communities; although non-native species are present throughout, especially in more disturbed areas. Common native overstory trees include cottonwood, alder, big leaf maple, Oregon ash, white oak, and Douglas fir. Common understory species include willow, vine maple, Douglas spirea, red osier dogwood, salmonberry, sword fern, Pacific ninebark, snowberry, Oregon grape, and Indian plum. Common non-natives are Himalayan blackberry, reed canary grass, scotch broom, and Japanese knotweed. Clark County continues to invest a lot of resources to combat non-natives along the floodplain.

A canopy height map is included in Figure 6. Canopy heights are estimated using LiDAR data, by subtracting the Digital Terrain Model (DTM) from the Digital Surface Model (DSM). The DTM is a surface developed from the ‘last return’ LiDAR pulses, and best represents the ground surface. The DSM is a surface developed from the ‘first return’ LiDAR pulses, and represents the highest points on objects in the landscape (tree tops, roofs of buildings, etc). These data mainly represent tree canopy heights, but can also pick up buildings and other structures. These data provide an overview of the vegetation size in the project area. The Dyer Creek, West Floodplain, Ridgefield Pits, and Daybreak Trail areas generally have short (young) vegetation, whereas the East Floodplain and County Yard areas have greater size diversity including trees exceeding 85 and 100 feet tall.

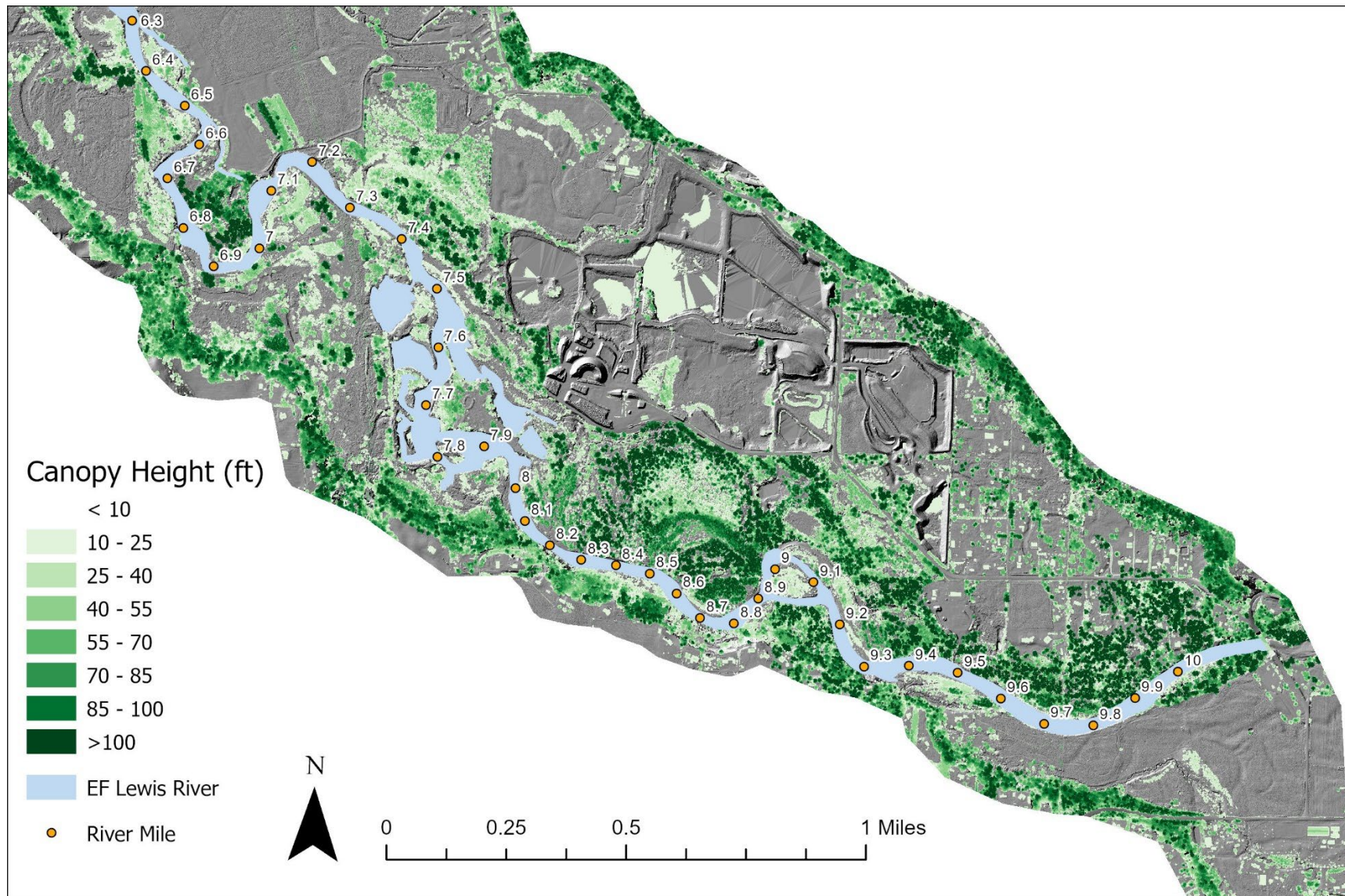


Figure 6. Canopy height map.

Map is created using the topobathy LiDAR data by subtracting the last return from the first return LiDAR pulses. Buildings will also be captured in this analysis. Some of the Daybreak Mine pits show coloration because they are greater than 10 feet deep.

2.1. Hydrology

2.1.1. Seasonal Flow Conditions

The EF Lewis River has a rainfall-dominated hydrograph typical of western Cascades streams. Estimates of average monthly flows for the downstream end of the project area (RM 7.5) are included in Figure 7. An exceedance plot showing the estimated median and the 10 and 90 percent exceedance flows for RM 7.5 is included in Figure 8. These values were obtained by using a basin-area correction of data from the USGS gage at Heisson (RM 20), which is approximately 11 miles upstream of the study area. Note the relatively steady median winter flow of between 1,000 and 2,000 cfs but the wide daily range. This demonstrates the high variation in winter flows. In contrast, summer base flows are very consistent, with an average median daily flow of 89 cfs in August.

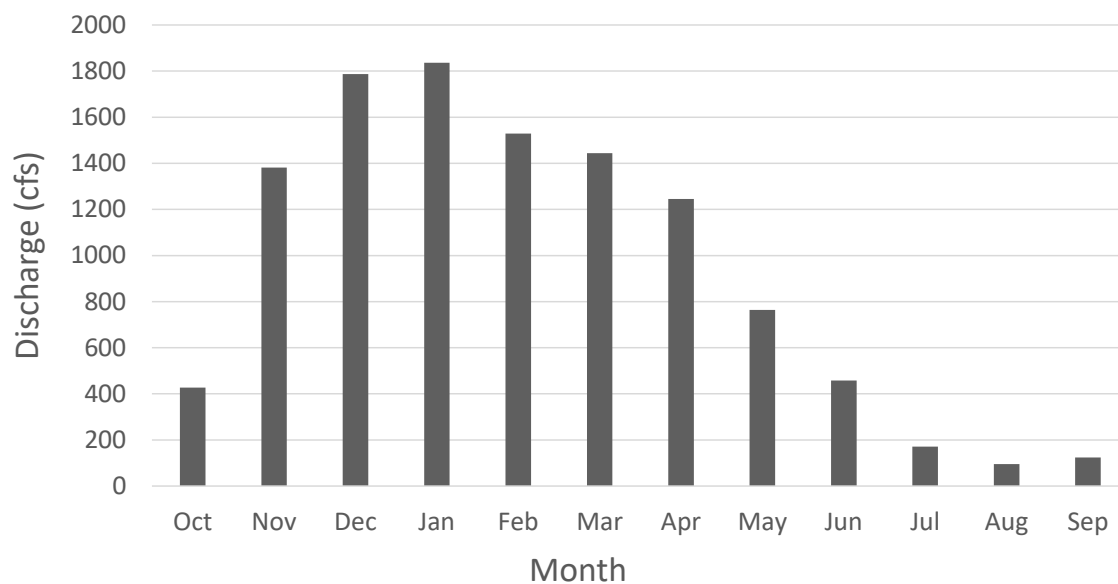


Figure 7. Average monthly flows for the project area.

This chart displays estimates of the average monthly flows for the project area, calculated using a basin-area correction on data from the Heisson Gage (USGS # 14222500) for the past 30 years (normals).

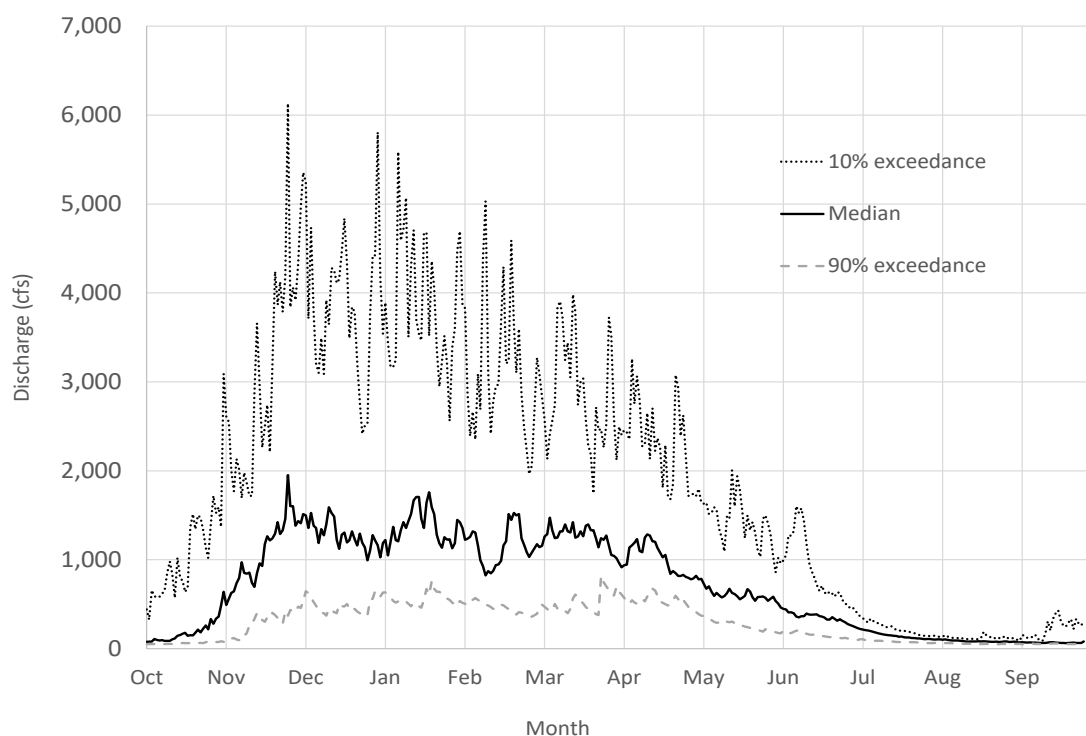


Figure 8. Daily flow exceedance for the project area.

Daily flow exceedance estimates were developed using a basin-area correction from the Heisson Gage (USGS # 14222500) for the past 30 years (normals).

2.1.2. Low Flow Conditions

The lowest flows on the East Fork Lewis typically occur from mid-August through early October. A gage operated by the Washington State Department of Ecology was in place just downstream of the Daybreak Bridge (RM 10.2) from 2005 to 2013. Minimum annual flows for the period of record are shown in Table 1. It should be noted, however, that most of these flows were tagged as “below rating”, which is assumed to mean the flows are lower than the values used to generate the rating curve, so they may contain errors. For reference, the corresponding minimum flows at the Heisson gage are generally higher, even though the gage is located 11 miles upstream. For example, on September 11, 2007, the minimum flow at Heisson was 36.1 cfs compared to 27.4 at Daybreak. Similarly, on September 8, 2011, minimum Heisson flows were 48 cfs compared to 26.7 at Daybreak. It is certainly possible that surface flow is lost to groundwater (i.e. losing reach conditions) once the river enters the broad alluvial valley downstream of Heisson. It is also possible that the rating curve from the Daybreak gage results in lower than actual base flows. With respect to losing versus gaining conditions in the lower East Fork, a 2005 study (Carey and Bilhimer 2009) performed seepage runs along the lower mainstem in August. Although only conducted during one year and time period (a June sampling event was judged to be unreliable), it showed that the reaches between Heisson and Daybreak were either gaining reaches (i.e. groundwater is contributing to surface flow) or there was no discernable difference in flows between reaches. These results bolster the idea that the minimum flows reported at the Daybreak gage may be inaccurately low. Correcting the Heisson gage daily exceedance values to Daybreak Bridge using a basin-area correction predicts that the lowest of the median daily flows get down to about 60 cfs in September and that the 90% exceedance flows (the flows that are exceeded

90% of the time) get down to about 50 cfs from mid-August through September. These flows may be a better representation of the low flows that can be expected to occur in the project area. For our flows used to support project design, we used 50 cfs as the base flow condition.

Table 1. Minimum flows 2005 to 2013.

Data are from the Daybreak Gage, which was operated just downstream of the Daybreak Bridge from 2005 to 2013 by the Washington State Department of Ecology.

Year	minimum flow (cfs)	Date	Notes
2005	56	September 29	Noted as being 'below rating'
2006	52.2	September 4	similar flows in late August
2007	27.4	September 11	Noted as being 'below rating'
2008	34.4	October 1	Similar flows in early September. Noted as being 'below rating'
2009	30.7	October 12	Similar low flows in Aug and September. Noted as being 'below rating'
2010	63	September 14	No data from July 26 to Sept 8
2011	26.7	September 8	Noted as being 'below rating'
2012	35.7	October 6	Similar flows since late Sept. Noted as being 'below rating'
2013	30.3	September 2	Similar flows mid-Aug to mid-Sept. Noted as being 'below rating'

2.1.3. Flood Flow Conditions

Estimates of flood discharges for a range of flood recurrence intervals were developed to support design analysis and hydraulic modeling. The methods recommended by Mastin et al. (2016) were used, following the procedures for “Estimating Flood Magnitudes at Ungaged Sites near a Streamgage”. The drainage area of the project site is less than 1.5 times the drainage area of the gage location, making it suitable for this procedure. This analysis was performed by first updating the flood recurrence estimates at the Heisson gage using a Log Pearson Type 3 analysis, which was performed using the software program Peak FQ (Flynn et al. 2006). These results are displayed in Table 2. A basin-area correction was then performed (Equation 11 in Mastin et al. 2015) to estimate the discharge values for the upper end of the site (near Daybreak Bridge, RM 10.2, Table 3) and for points below the significant tributaries including Manley, Mill, Dean, and Dyer Creek. Tributary flows, for modeling, were calculated using the differences between these point values.

Table 2. Flood flow estimates for Heisson Gage.

USGS 14222500 EAST FORK LEWIS RIVER NEAR HEISSON, WA					
LP3 from PeakFQ, run April 11, 2023					
Drainage area (sq mi)		125			
B17B method. Weighted skew. Regional Skew -0.07, Standard Error 0.4243, MSE 0.18 from Mastin et al (2015)					
Return Period	Annual Exceedance Prob	Lower 5% CI	BULL.17B	Upper 95% CI	
1.005	0.995	2532	3005	3450	
1.01	0.99	2865	3355	3812	
1.05	0.95	3994	4518	5003	
1.1	0.9	4751	5285	5785	
1.25	0.8	5834	6382	6908	
1.5	0.6667	7026	7598	8173	
2	0.5	8473	9108	9793	
2.3	0.4292	9133	9814	10570	
5	0.2	11930	12920	14130	
10	0.1	14140	15470	17200	
25	0.04	16860	18710	21230	
50	0.02	18850	21140	24310	
100	0.01	20810	23570	27470	
200	0.005	22780	26020	30700	
500	0.002	25380	29320	35110	

Table 3. Flood flow estimates for project area.

Basin Area Correction to Daybreak Bridge (RM 10.2)						
Using Mastin et al. 2015 equation 11						
Drainage area (sq mi)		154.28	19% diff from gage			
					b coef fr Mastin Tbl 6 (red=assumed).	
Return Period	Annual Exceedance Prob	Lower 5% CI	B17B	Upper 95% CI	Reg 4	
1.005	0.995	3067	3640	4179	0.911	
1.01	0.99	3470	4064	4618	0.911	
1.05	0.95	4838	5473	6060	0.911	
1.1	0.9	5755	6402	7008	0.911	
1.25	0.8	7067	7731	8368	0.911	
1.5	0.6667	8511	9204	9900	0.911	
2	0.5	10264	11033	11863	0.911	
2.3	0.4292	11065	11891	12807	0.912	
5	0.2	14457	15657	17123	0.913	
10	0.1	17143	18755	20853	0.915	
25	0.04	20453	22698	25755	0.918	
50	0.02	22879	25659	29507	0.9205	
100	0.01	25258	28608	33342	0.9205	
200	0.005	27664	31599	37282	0.923	
500	0.002	30841	35629	42665	0.926	

A graphical display of annual peaks since the 1930s is provided in Figure 9. As can be seen, three flood events in the past 25 years have met or exceeded the 50-year event; and the February 1996 event, which is the flood of record, is near the 500-year event. From Figure 10, it also appears that since the 1970s, there has been greater variation in the size of peak flows, which is possibly related to basin land use such as increases in the road drainage network, timber harvest, and conversion of forest to other uses.

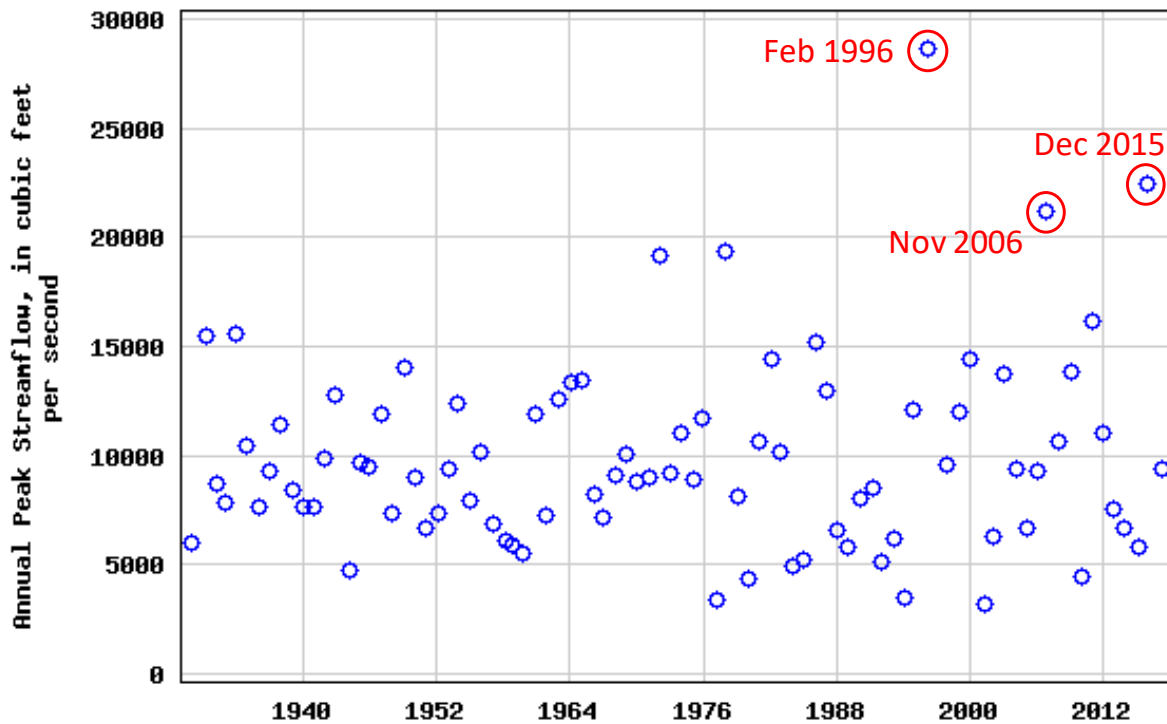


Figure 9. Annual peak flows.

This chart displays annual peaks for the period of record from the Heisson Gage (USGS #14222500). Recent and prominent flood events over the past 25 years are highlighted.

2.2. Fish Use

In 2001, WDFW produced a report (Project # 99- 1113P) that estimated coho and smolt production from the EF Lewis River above RM 6. Estimates of steelhead production in 2001 included hatchery production (prior to the EF Lewis River becoming a wild steelhead gene bank) and included 12,481 wild smolts and 106,836 hatchery smolts. Smolt estimates for other species included: 5,716 coho, 2,060 chum and 1,068 sea-run cutthroat. Spawning data have not been collected by WDFW in the pits area (with the exception of the area above Pit 1) due to avulsion and lack of suitable habitat. Historical accounts of the area where the avulsion occurred suggest that it hosted valuable spawning and rearing habitat due to the availability of spawning gravels and suitable depths and velocities.

As part of the Storedahl HCP (2003) requirements in Conservation Measure 10 (CM-10) R2 Consultants (2013) collected fish data in the Ridgefield Pits. There were no data collected within the EF Lewis River adjacent to the pits, upstream or downstream of the pits. The survey, which included 23 minnow traps and snorkeling, occurred from July 30-31. The results of the R2 survey showed 500 yearling coho around Pit 2 in an area fed by cooler groundwater. No other juvenile salmon or steelhead were observed.

The Estuary Partnership conducted presence/absence surveys for salmonids during the summers of 2018 and 2019. The data collection was accomplished using two teams and using a snorkel survey approach. Data collection occurred in June and August 2018 and again in August 2019. The surveys began at Daybreak Park and terminated below the Ridgefield Pits. As part of the June 2018 survey, presence/absence data were collected from each of the nine pits. Although the Estuary Partnership

methodology was different from the R2 survey, the follow-up survey allowed for validation of R2's findings.

The results from the surveys showed juvenile fish present in almost every section of the river throughout the project reach. Figure 10 shows results from the June 2018 survey, which includes salmon and steelhead observed within the project area from RM 7.5 - 10. Locations of the juvenile fish shown in Figure 10 are approximate. Juveniles that were found included yearling and sub-yearling steelhead, coho and Chinook. Several adult steelhead were also observed (not shown). The juveniles were often found clustered (particularly coho and Chinook) in and around structure (wood), in areas that had cooler water and in tail-outs (primarily steelhead). In the June 2018 survey, several of the pits (8 and 9) contained much cooler water and 360 juveniles were found in Pit 8. The 550 fish that were found around Pits 1 and 2 compare favorably to R2's findings and suggest that this is an important area for juveniles. Juvenile salmon and steelhead were also found in and around Pits 1, 2, 8 and 9. In the other pits, and in the river where depths were greater than several feet, warm water species were frequently observed.

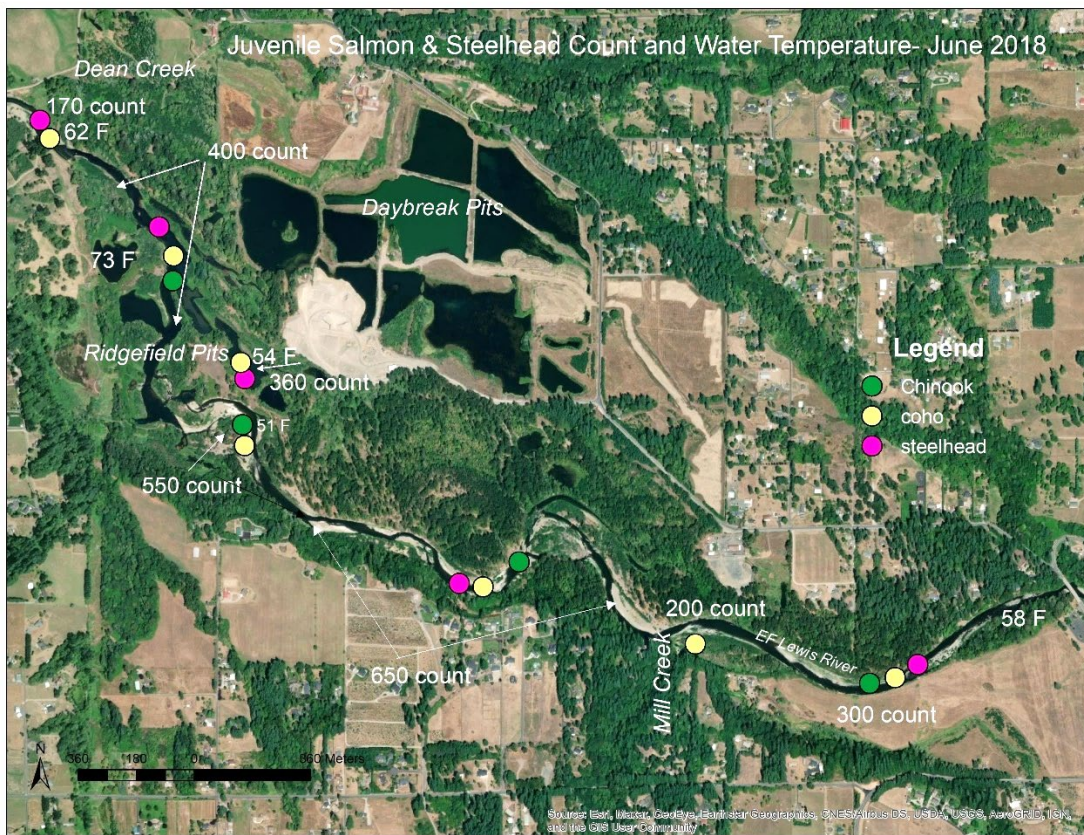


Figure 10. Salmon and steelhead counts.

Count estimates for salmon and steelhead and temperature observations based on 2018 snorkel survey. Flow is from right to left.

3. Design Investigations

3.1. Topobathymetric Data Collection

3.1.1. Topobathymetric LiDAR and Aerial Photo Collection

Topobathymetric Light Detection and Ranging (LiDAR) data were collected on June 26, 2022 by NV5 Geospatial. The LiDAR data have been used in combination with ground survey data to support hydraulic modeling, design grading, and other components of design. The area covered included the East Fork Lewis River valley bottom from NE Stoughton Road upstream to Daybreak Park (approximately RM 6 – 10.5). Traditional near-infrared (NIR) LiDAR was integrated with green wavelength (bathymetric) LiDAR to provide a complete topobathymetric lidar dataset. Due to some limitations of the bathymetric LiDAR collection, some areas in deep or turbid waters were not captured. Other areas with very thick groundcover, such as Himalayan blackberry thickets, were also not fully captured. For this reason, ground and bathymetric surveys were performed to supplement the LiDAR data; these are described in the section below. In addition to the topobathymetric coverage provided by the LiDAR, comparing the first (highest hit) and last return data were used to help map tree canopy height throughout the project area.

High resolution digital aerial imagery was collected at the same time as the LiDAR flight. This has been used to support designs and planset development.

The topobathymetric and aerial photo report is included as Attachment 3.

3.1.2. Topographic ground surveys

As described above, the topobathymetric LiDAR data was supplemented with ground-based topographic and bathymetric data collected in October 2022 and April 2023 by LCEP and Inter-Fluve staff. The field survey effort was focused on data gaps where coverage was limited in the LiDAR data set. These areas generally consisted of the pit areas, deep pools in the current mainstem river, and areas within the pits complex covered in dense vegetation such as Himalayan blackberry. Survey data were collected using a combination of GPS RTK, Total Station, and a single-beam sonar system mounted on a boat and connected to GPS RTK.

These data were combined to create the existing conditions digital terrain model used for modeling and design analysis (see Section 3.5.1).

3.2. Sediment and Subsurface Investigations

3.2.1. Pebble counts - 2018

LCEP and Inter-Fluve conducted surface layer and sub-armor layer pebble count surveys at selected floodplain and mainstem locations within the project area in October 2018. These data are included in Attachment 6. These data were originally collected to support 2D sediment transport modeling by LCEP and have been used to generally characterize the bed substrate conditions in the project area and the size of material that would be expected to enter the Ridgefield Pits reach over the coming years. These data showed that the D50 of the surface armor layer on mainstem bars in the reaches upstream of the Ridgefield Pits ranged from 34-73mm (coarse to very coarse gravels). The D84 ranged from 57-150mm (very coarse gravel to medium cobbles). The D50 of the sub-armor on mainstem bars ranged from 4-

17mm (fine to medium gravel), with the D84 from 16-39mm (medium to coarse gravel). Grain sizes in side-channels or other areas away from the mainstem were smaller.

Photographs were also taken of the actively eroding streambank on river-right at the top of the Ridgefield Pits reach, indicating mostly fines but also a mix of grain sizes ranging from silts to cobbles. Additional photo-documentation of this bank was again performed in 2023 (see Section 3.2.2).

3.2.2. Subsurface Investigations

Subsurface investigations were performed by Inter-Fluve and LCEP staff over the course of three field surveys: 1) September 2022; 2) April 2023; and 3) September 2023. The September 2022 survey mainly focused on the West Floodplain area, but also looked at conditions within the Ridgefield Pits. The April 2023 survey focused on the East Floodplain area, but it also investigated conditions within the Ridgefield Pits. The September 2023 survey, which also included vibratory pile driver testing, was over the course of 3 days and spanned the West Floodplain, Ridgefield Pits, East Floodplain, Danger Park, and County Yard sites. The September 2022 and September 2023 surveys occurred in conjunction with geotechnical investigations described below in Section 3.2.3. The results of these investigations are summarized in Attachment 1.

The subsurface investigations were intended to characterize subsurface sediment conditions to inform the grading plan. In particular, it was necessary to obtain a general understanding of the depth and volume of coarse substrate (gravels and cobbles) that would be available to use for channel construction in the new channels through the Ridgefield Pits reach or other areas that may require coarse substrate to achieve adequate channel stability or ballast for large wood structures. The investigations entailed digging test pits with a backhoe or excavator and documenting the material using soil profiles, photographs, notes, and in some cases, lab grain size analysis. Test pits were located throughout the West Floodplain, Ridgefield Pits complex, East Floodplain, Danger Park, and County Yard. Overall, over 50 test pits or exploratory digs were performed. In addition, bank exposures within the Ridgefield Pits reach were documented with photos and notes. These data, along with the subsurface investigations performed as part of the geotechnical investigations and sediment quality sampling (described below), have been used to provide a general understanding of the character of the subsurface materials and the approximate availability of coarse material that can be used in the grading plan. In total, given all of the subsurface investigations to date, there are approximately 74 subsurface test points, made up of machine-dug test pits, exploratory machine-based digs (e.g. into levee material), and drilled borings (see Figure 11). Despite these investigations, due to the size of the project area, there will still remain some uncertainty with respect to the total volume of coarse material that will be available, and the designs have been configured accordingly.

3.2.3. Geotechnical Investigations

Geotechnical investigations were performed in the West Floodplain area for three purposes: 1) provide data to support the potential design of transmission tower protections (no longer necessary), 2) provide data to support the potential design of utility vehicle access bridges over potential new side-channels (*now removed from the design) to maintain adequate access to the BPA transmission lines and towers, and 3) provide data to support the design of a bridge over the proposed new location of lower Dyer Creek. The initial field investigations were performed in September 2022 using rotosonic borings near each of the three powerline towers and backhoe-dug test pits in the vicinity of where bridges over

side-channels would have been located. A follow-up geotechnical survey occurred in September 2023 to observe a test pit dug near the future potential bridge crossing of lower Dyer Creek, which is likely to be constructed as part of the separate Dyer Creek project.

Qualitative geotechnical survey and review was also performed along the margins of the floodplain along the Storedahl Pit Road and Daybreak Mine processing area on November 4, 2022. The purpose was to gain an understanding of any current slope stability issues and to identify any areas of existing bank armoring. Only minor recent erosion was documented, and this was related to stormwater runoff from the road and processing facility, not from the river. No bank armoring was identified. This information has helped inform the design of the Ridgefield Pits grading and the East Floodplain side-channels. In general, due to a lack of existing armoring, measures have been taken to avoid the potential for causing an increase in flow energy along this margin.

The geotechnical analysis report is included as Attachment 2.

3.2.4. Soil Quality Sampling

Soil quality was investigated in three areas of the project where excavation will occur and where the material will be used as part of the grading plan for the project. The three areas all have had past or current land-uses including gravel mining and heavy equipment use. Soil testing occurred as part of environmental due diligence and to increase the certainty of the soil quality in these areas prior to construction. The three focus areas for testing included the following: 1) Ridgefield Pits central high ground, which was the staging and sorting area for the Ridgefield Pits gravel mining operation in the 1990s; 2) Danger Park berm, which borders the Danger Park pond, a former mining pit; and 3) the County Yard site, which is currently an active sand and gravel sorting and staging site and that is being proposed to be re-located as part of the project. A total of 14 test pits were excavated to depths ranging between 5 and 9 feet below ground surface. Soils were classified using the United Soil Classification System and were screened for volatiles in the field using a photoionization detector (PID). A total of 15 composite samples were laboratory tested for total petroleum hydrocarbons (TPH). Field screening, visual/olfactory observations, and laboratory testing did not indicate that TPH impacts were present in any of the 14 test pits. A PID reading of 2.5 ppm (parts per million) in one of the test pits was believed to be due to the presence of subsurface organics. These results suggest that the material excavated in these areas is appropriate for use as clean backfill for other areas of the project. However, the sampling report does provide guidelines for monitoring subsurface conditions during project construction, and procedures for segregation, storage, and disposal of contaminated soil if it is encountered. The soil quality sampling technical memo is included as Attachment 10.



Figure 11. Summary map of all subsurface investigations including exploratory test pits, geotechnical pits and borings, and soil sampling locations.

3.3. Wetlands Delineation

Much of the valley bottom is comprised of a matrix of wetlands and EF Lewis River channels. To evaluate potential impacts to existing sensitive habitats, including wetlands, LCEP conducted a wetland field delineation within the proposed limit of disturbance. The wetlands report is included as Attachment 4, and is summarized below.

The approach to wetlands delineation was discussed with regulatory agency (USACE/WA Dept of Ecology/WDFW/Clark Co.) staff during field meetings that were held on September 8, 2022. Agency staff agreed that the approach being taken to the wetland delineation was appropriate and that LCEP should continue to field delineate all wetlands within the project site limits. Agencies also discussed the approach to permitting and stated that the project design should not result in a loss of area of wetlands or a loss in linear feet of perennial stream bed, and that “compensatory mitigation” is not required since the project design will result in net increases in aquatic resource function and services.

The wetland delineation was performed iteratively beginning in June 2022 and continuing through September 2023, as areas of work evolved with the design. All portions of the site were walked, and wetlands were delineated as they were encountered. Wetland boundaries were flagged at intervals appropriate to follow wetland contours. Each wetland flag was individually surveyed using survey grade GPS (TopCon HiPer VR) survey equipment. This survey equipment has accuracies of 3mm horizontally and 5mm vertically. Data on vegetation, soils and hydrology were collected at representative upland and wetland boundaries and wetland data forms were prepared.

LCEP staff identified and delineated a total of 32 separate wetlands, totaling 66.07 acres, within the EF Lewis Study Area, which includes the Dyer Creek project area. These wetlands are lettered A through QQ. The majority of the wetlands were in the vicinity of the nine (9) former Ridgefield Pits or associated with the former alignment, prior to the 1996 avulsion, of the EF Lewis River. The wetlands have each been rated according to the Washington Wetland Rating system – Western Washington and wetland standard buffer widths were determined following Clark County Code. The wetland summary table (Table 4) provides additional detail on each of the wetlands.

Table 4. East Fork Lewis River Project Site Wetland Summary Table

Wetland ID	Area (acres)	Area (square feet)	HGM	Cowardin	Wetland Category ¹	Buffer Distance (feet, low intensity use) ²
A	16.65	725,333.00	Riverine	PUSA/PEM1A	II	150
AA-BB	10.88	474,079.10	Riverine	PAB1F	II	150
B	0.78	33,943.27	Riverine	PSS1C	II	150
C	0.41	17,718.26	Riverine	PEM1C	II	150
CC	0.04	1,709.12	Depressional	PFOA	III	75
D	0.07	2,963.06	Depressional	PUSA	IV	25
DD	0.76	33,216.72	Riverine	PFOA	II	150
E	0.4	17,207.66	Riverine	PEM1C	II	150
EE	1.6	69,771.94	Depressional	PEM/PSS	II	75
F	0.83	35,979.29	Riverine	R2UBH	II	150
FF	0.15	6,484.69	Depressional	PSS/PFO	III	75
G	0.69	29,864.01	Riverine	R2UBH	II	150
GG	0.07	3,074.33	Riverine	PFOA	III	75

H	0.07	3,253.56	Depressional	PEM1A	IV	25
HH	8.37	364,771.80	Riverine	PEM1A	II	150
J	0.06	2,765.85	Depressional	PFOC	II	150
JJ	2.2	95,939.31	Riveirne	PEM/PFOA	II	150
K	6.98	304,158.30	Riverine	PSS1A	II	150
KK	1.42	61,671.19	Riverine	PEM2/PFOA	III	75
L	0.14	6,297.32	Riverine	PSS1A	III	75
LL	0.17	7,434.69	Depressional	PFO1D	III	75
M	0.11	4,982.40	Riverine	R2UBH	III	75
MM	0.05	2,122.66	Riverine	PSS1E	III	75
NN	0.01	432.86	Riverine	PFO/PSS1D	III	75
N-P	7.4	322,491.90	Riverine	PSS/EM1A	II	150
OO	0.04	1,573.96	Riverine	PSS1A	III	75
PP	0.03	1,199.94	Riverine	PSS1A	III	75
T	0.07	2,893.43	Depressional	PSS/EM1A	III	75
U-V-Y	4.47	194,699.00	Riverine	PUBF	III	150
X	0.53	23,019.79	Riverine	PUBHx	III	75
Z	0.61	26,563.51	Riverine	PSS/EM1C	II	150
QQ	<0.01	282.77	Riverine	PFO	IV	25
Total	66.07	2,877,910.26				

¹Washington Wetland Rating System (Washington Tool for Online Rating - WATOR)

²Wetland Buffers per Clark Co. Code 40.450.030 – Standards

The EFLR and several other streams are located within the Study Area. The ordinary high-water marks (OHWM) of these features were delineated using a combination of methods described in the publication *Determining the Ordinary High-Water Mark for Shoreline Management Act Compliance in Washington State* (Anderson et al. 2016) and hydrological modeling conducted by IFI. Model results were then checked on the ground to confirm the presence of indicators of flow. Perennial streams within the Study Area include the EFLR, Dyer Creek, Manley Creek, and No Name Creek. Two small seasonal creeks that originate from hillside seeps were mapped in the southern portion of the Study Area.

Additionally, Pit 9 is located adjacent to the EFLR, within the 200-ft shoreline band and 100-year floodplain. This feature (OW-1) is a 1.37-acre open water pond with a small amount of floating emergent vegetation on the narrow shallow fringes (<30% vegetation cover).

The delineated wetland and stream boundaries and accompanying report do not constitute a permit application, but rather should be considered a preliminary jurisdictional determination of wetlands and waters. Final authority for the approval of the wetland boundary delineation lies with the Washington Department of Ecology and the United States Army Corps of Engineers.

3.4. Water Temperature

3.4.1. Overview

LCEP completed a water temperature analysis for the project area to analyze factors contributing to the existing summertime temperature profile and predict how water temperature may respond to various restoration alternatives. The analysis relied on previous temperature studies as well as temperature surveys completed in July 2018 and August 2020. These utilized continuous temperature loggers at

several locations in the mainstem and floodplain, as well as a single thermal infrared survey completed for several miles of the East Fork Lewis River mainstem in 2020. A 2D water temperature model was created to compare temperature performance of restoration alternatives that were developed for the Ridgefield Pits reach, including the preferred Alternative #3 (three-channel network) and Alternative #2 (single-channel network). These alternatives are described further in Section 4 and in Attachment 7.

The temperature model is an advective/dispersive heat transfer add-on module for the Tuflow FV hydraulic model engine, which includes atmospheric inputs for heat exchange at the air-water interface. The complete water temperature analysis is included as Attachment 9 to this report. A summary of the findings is presented below.

3.4.2. Results Summary

The following bullets summarize water temperature characteristics for the project area during low flow summer conditions when temperatures are of concern:

- EFLR mainstem temperatures already exceed most water quality standards at the upstream extent of the Project reach near RM 10 at Daybreak Park.
- Further degradation of EFLR temperature through the Project reach is minimal.
- EFLR mainstem temperature exhibits large diurnal variation in summer due to atmospheric heating and cooling. This variation is reduced through the Ridgefield Pits, where the high volume of slow-moving water attenuates heating and cooling effects, resulting in lower daily high and higher daily low temperatures relative to upstream and downstream reaches.
- Much of the spatial variation in temperature observed in the vicinity of the Pits can be attributed to the moderating effect of the Pits reach on atmospheric heating and cooling. Temperature modeling supports this conclusion.
- Some groundwater may currently influence water temperature through the Pits reach, but this appears to be a relatively small influence, at least during the period we monitored.
- Groundwater influence is tied to the water table, which fluctuates based on climate and weather patterns. Thus, influence of groundwater on the EFLR mainstem is likely to vary from year to year. This has been evidenced by LCEP's 2021 water temperature monitoring, which showed considerably less cold water in off-channel and side channel areas relative to 2018.
- Little evidence of mixing is observed between the larger Ridgefield Pits #5 and #7 and the EFLR mainstem despite being hydrologically connected throughout the summer. Model results support this conclusion.
- Several off-channel and side channel areas have been observed to hold cold surface water during the summer, presumably due to groundwater intrusion. Most of these however do not remain hydrologically connected to the EFLR mainstem during most summer flows, limiting their potential as thermal refuge for juvenile salmonids.
- The confluence of Mill and Manley creeks with the EFLR mainstem presents the largest area of current thermal refuge within the Project reach.
- Overall, the highly dynamic nature of the project reach results in a complex and dynamic water temperature profile. Restoration actions should retain and enhance positive aspects of this.

3.4.3. Implications for Restoration Alternatives

The following bullets summarize implications of the observed and simulated EFLR temperature performance for the restoration alternatives that have been considered for the Pits reach, relative to each other and the Existing Condition.

Existing Condition:

- Slow moving, large volume of water with reduced diurnal temperature variation relative to upstream and downstream. Lower daily maximum and higher daily minimum temperatures.
- No current riparian shading, and not likely to improve due to large channel widths.
- From a temperature standpoint, the larger pits (#5 and #7) which remain connected to the mainstem during summer do not appear to degrade its temperature. Other negative factors such as habitat for predators must also be considered.

Alternatives #2 and #3, relative to Existing:

- Based on modeling, water temperatures for both Alternatives will likely exhibit the larger diurnal temperature variations currently seen upstream and downstream of the Pits reach. Thus, daily peak temperatures will be higher, and daily minimum temperatures will be lower, relative to the Existing condition.
- Overall water temperature may be reduced relative to the Existing Condition due to an anticipated rise in the groundwater table from proposed grading.
- Extensive riparian planting along channels that are considerably narrower than the Existing Condition should provide extensive shading and reduce solar heating of the reach during the day, potentially reducing diurnal temperature variation.

Alternative #2 versus #3

- Model results indicate slight improvement in temperature performance for the hybrid three-channel network in Alternative 3 versus the single channel in Alternative 2. Despite the greater water depth and smaller width-to-depth ratio exhibited by Alternative 2, the corresponding reduction in heating is offset by a greater overnight cooling effect seen in the shallower, smaller Alternative 3 channels.
- Temperature performance in Alternative 3 was seen to be further enhanced by simulated groundwater inputs, which persist longer and have more influence in the shallower, lower volume multi-thread channels relative to the single channel.
- Due to time constraints, channels for the Alternative 3 design were not optimized for low flow. Further iterations of low-flow geometry may be possible to further enhance its temperature performance.

3.5. Hydraulics

This section describes the hydraulic analysis that began following the completion of the Preliminary (30%) Design. For the Preliminary Design, the Estuary Partnership performed the hydraulic modeling using the TUFLOW FV hydraulic model, which is described in the Preliminary Design report.

For analysis following the completion of the Preliminary (30%) Design, the hydraulic analysis was conducted using two-dimensional (2D) hydraulic models that were developed for existing conditions and the proposed design conditions within the U.S. Army Corps of Engineers HEC-RAS 6.3.1 software. 2D hydraulic computations are typically superior to one-dimensional (1D) computations when detailed analysis of river systems with multiple channels or flow paths is required, or where flow is lateral or complex across wide floodplains. 2D computations were chosen for this project model to analyze split flows and channel-floodplain interactions under a variety of hydrologic conditions.

3.5.1. Modeling Geometry

3.5.1.1. *Digital Terrain Model-Existing conditions*

The existing conditions digital terrain model (DTM) was developed using the topobathymetric LiDAR data supplemented with the topographic and bathymetric data collected in 2022 (See section 3.1 for a description). A composite DTM consisting of LiDAR and survey data was developed by Inter-Fluve and incorporated into the hydraulic model.

3.5.1.2. *Digital terrain model-proposed conditions*

Proposed conditions grading features were initially incorporated into the DTM using the built-in surface manipulation features in HEC-RAS. These features were primarily used for alternatives screening and preliminary design iterations. Once the general proposed feature layout was determined, grading surfaces were developed in AutoCAD Civil3D software and incorporated into a proposed conditions DTM surface using the combined existing conditions DTM as a base.

3.5.1.3. *Computational Domain*

The computational domain for the project model extends from the Mason Creek-East Fork Lewis confluence at the downstream end to the Daybreak Bridge at the upstream end. The width of the model domain spans the valley such that the modeled inundation extents of large floods are adequately contained within the model domain. An overview of the computational domain is provided in Figure 12.

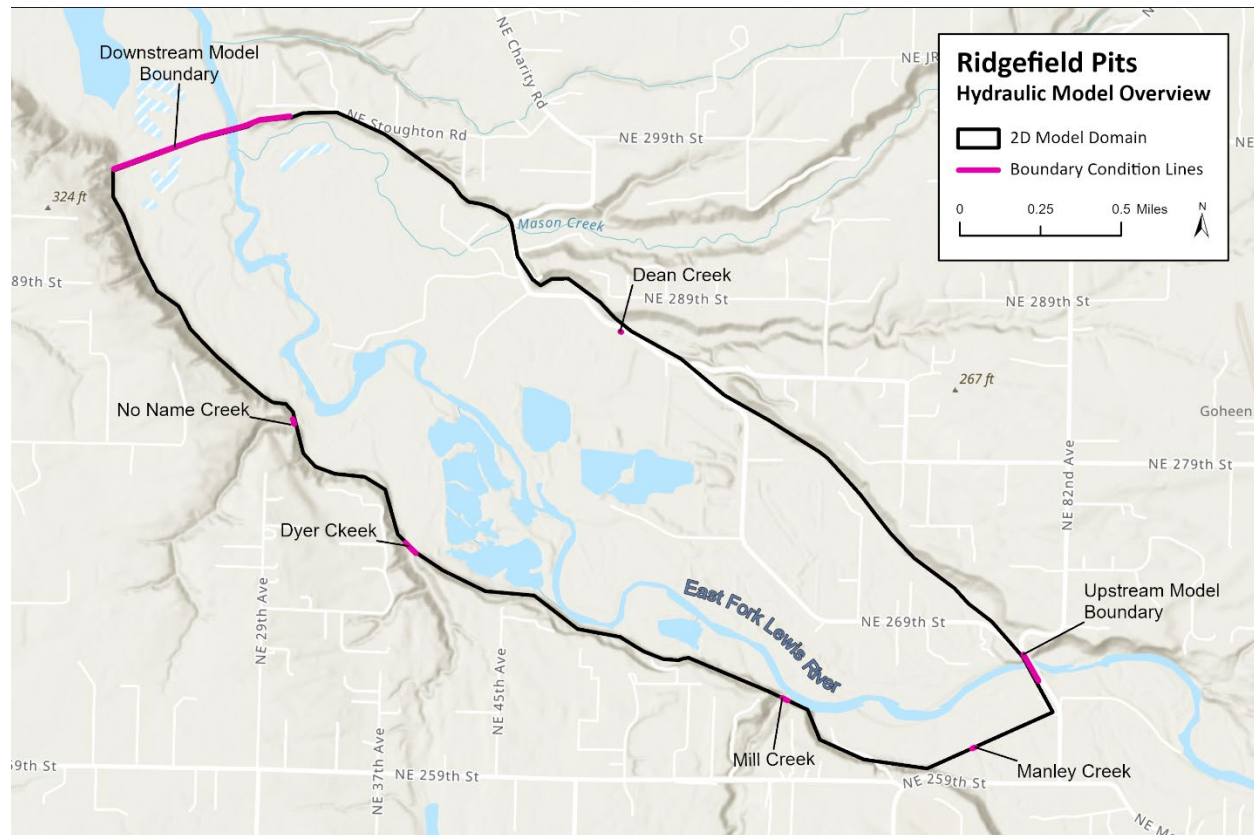


Figure 12. Overview of the 2D model domain.

The 2D model geometry used a flexible computational mesh adjusted according to terrain complexity and areas of interest. The nominal mesh spacing for pre-project conditions ranges from 15 ft within the main EF Lewis channel to 40 feet in relatively homogenous areas of the floodplain, with smaller cell sizes applied to areas where higher resolution results were desired. Breaklines were added along the tops of banks, channel alignments, and prominent high ground features to further refine the mesh. The computational mesh for proposed conditions is similarly configured, however, breaklines were revised to represent proposed features and the nominal mesh spacing within proposed side channels was reduced to 12 ft.

3.5.2. Input Parameters

3.5.2.1. Boundary Conditions

Inflow hydrographs for the EF Lewis River and tributaries within the reach were based on the discharges described in Section 2.1.3 and listed in Table 3. These discharges were incorporated into a synthetic hydrograph with periods of steady flow (at the discharges of interest and other intermediate discharges) connected by smooth transition periods to create a stair-step like pattern. The periods of steady flow allow the model to come to a quasi-steady state condition, which facilitates the interpretation of hydraulics at specific discharges. The timing of each of the steady-state “peaks” was assumed to occur simultaneously between the tributaries and EF Lewis mainstem to simplify the interpretation of results and provide conservatively high results with respect to inundation during large flood events. A demonstrative quasi-steady state hydrograph is provided in Figure 13.

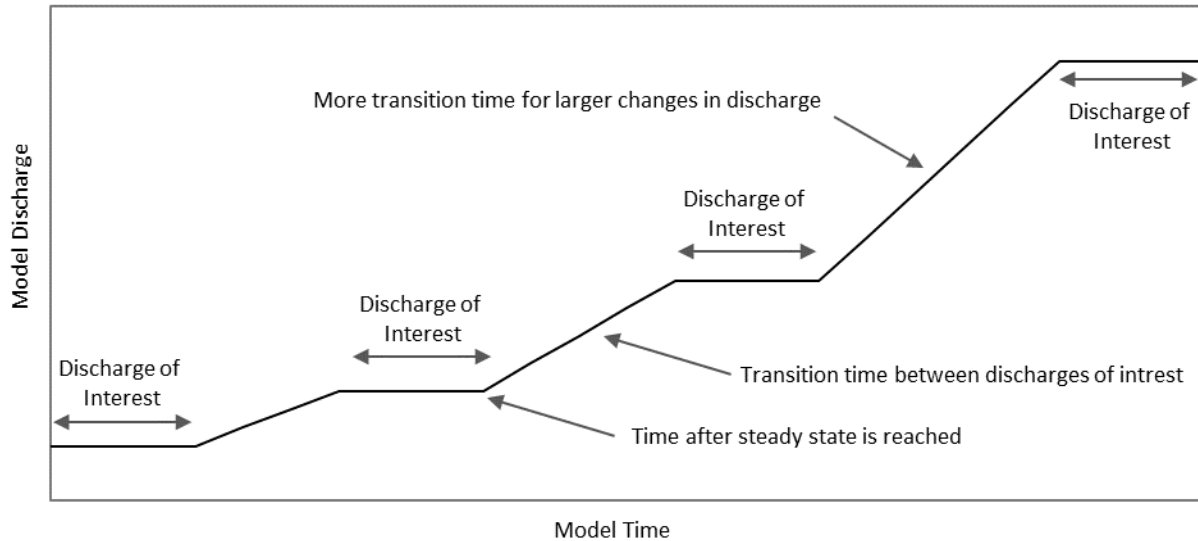


Figure 13. Demonstrative quasi-steady state hydrograph used to model flow inputs.

The downstream boundary condition consisted of a model-derived stage-discharge rating curve from a calibrated model (TUFLOW FV) prepared by the Estuary Partnership for the Preliminary Design. The downstream boundary was placed a substantial distance downstream of the proposed project area to dampen the effects of any potential uncertainties related to the downstream boundary condition. The rating curve used as the downstream boundary condition is displayed in Figure 14.

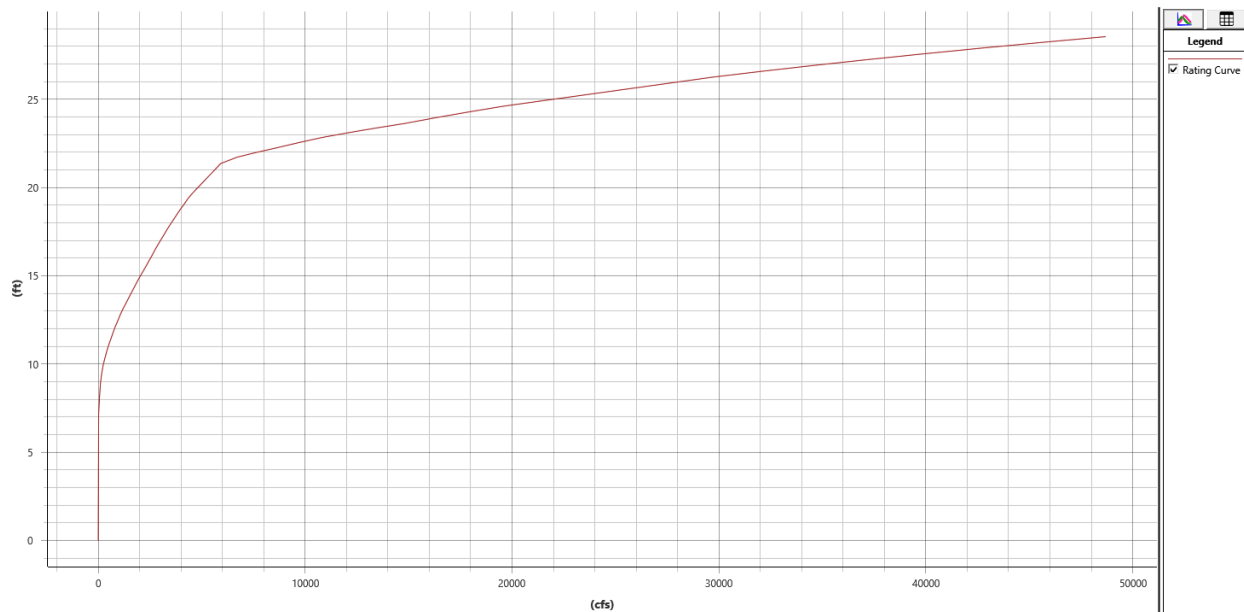


Figure 14. Rating curve used as the downstream boundary condition.

Given that the current version of HEC-RAS does not allow for modeling subsurface flow, additional inflow boundaries were applied to the largest pits at the start of the simulation, to fill the pits with water prior to surface water overtopping the existing levees. Filling the pits was only required in existing conditions simulations, and the pit boundary lines were removed for proposed conditions simulations.

3.5.2.2. Hydraulic Roughness

A spatially varying roughness (Manning’s *n*) layer was created by using a combination of LiDAR-derived canopy height data and hand-digitizing regions with similar land cover. Canopy height data were used throughout much of the floodplain, and classification bins were iteratively adjusted based on field observations. Land cover regions were hand delineated in areas such as the active channel, open water, gravel bars, and wetlands. In general, roughness values were applied to these regions based on field observations, aerial photos, and professional judgement. The initial roughness layer was provided by the Estuary Partnership using landcover data, and starting roughness assumptions were based on a calibrated hydraulic model that has been refined over multiple years of data collection. Table 5 summarizes the roughness coefficients used in both the existing and proposed conditions models.

Table 5: Roughness coefficients used in the 2D model.

Land Cover Region	Manning's n Value
Bare Ground	0.03
Open Space (0.1 – 0.5 ft Veg Ht)	0.05
Low Shrub (0.5 – 2 ft Veg Ht)	0.07
Moderate Density (2 – 4 ft Veg Ht)	0.065
Very Dense (4 – 10 ft Veg Ht)	0.2
Dense (10 – 15 ft Veg Ht)	0.15
Riparian (15-30 ft Veg Ht)	0.12
Mixed Forest (30 – 60 ft Veg Ht)	0.1
Forest (60 -100 ft Veg Ht)	0.08
Large Tree (>100 ft Veg Ht)	0.065
Channel (sand, small gravel, muck)	0.025
Channel (gravel, cobble)	0.03
Channel-large pool	0.02
Gravel Bar	0.03
Cobble Bar	0.037
Vegetated Bar (density varies)	0.045 – 0.08
Coarse Bank	0.042
Wetland, Beaver Ponds	0.1
Backwater slough	0.08
Proposed- Main channel	0.045
Proposed- Side Channel	0.075
Proposed- Vegetated Gravel Bar	0.06
Proposed- Floodplain Grading	0.065
Proposed- Wetland	0.08

3.5.3. Calibration and Validation

Model calibration was performed using the initial TUFLOW FV model calibrated by the Estuary Partnership, which was based on multiple years of field data collection. Additional model calibration

was performed using water level data collected within the project area as part of design surveys; however, given the uncertainty related to flows in the project reach and groundwater inputs, a qualitative calibration approach was used. The model results were validated based on field observations and professional judgement.

3.5.4. Modeling results

Hydraulic model outputs of depth and velocity for a range of flow conditions for existing and proposed conditions are provided in Attachment 8.

4. Alternatives Analysis

4.1. Overview

An alternatives analysis was performed that looked at a suite of restoration alternatives for the site. This process was informed by input from a Technical Oversight Group (TOG) made up of agency, landowner, and technical representatives familiar with the lower East Fork Lewis. As early as 2018, the TOG began meeting to discuss the condition, needs, and potential approaches for restoration of the lower East Fork Lewis in the vicinity of the Ridgefield Pits. The group reviewed and commented on project goals and objectives, which provided the foundation for the restoration alternatives and are included in Section 5.1. The alternatives analysis was completed in 2020. Restoration alternatives primarily focused on the Ridgefield Pits themselves, with consideration also of actions in upstream areas, primarily focused on side-channel and off-channel habitat enhancements. The preferred alternative from this process essentially represents the current approach for restoration of the Ridgefield Pits. However, due to further analysis and project evolution, the upstream elements have been modified and in some cases eliminated from consideration, and additional upstream as well as downstream actions have been added.

4.2. Summary of Restoration Alternatives

The restoration alternatives and the associated alternatives analysis is summarized in the Alternatives Analysis report (Attachment 7), which includes concept-level sketches of each alternative. The alternatives analysis involved the development and evaluation of 6 alternatives, including a No Action alternative. Not all of the alternatives were mutually exclusive, allowing for the selection of “a la carte” items that could be grouped together. The restoration alternatives that were evaluated are listed below:

- Alt. 1 – No action- passive recovery of Ridgefield Pits
- Alt. 2 – Relocate main channel EF Lewis River into pre-avulsion channel (single-thread)
- Alt. 3 – Full Ridgefield Pits re-grade and multi-thread channel network
- Alt. 4 – Side-channel enhancements at upper and lower sites
- Alt. 5 – Mill/Manley Cr. confluence improvements
- Alt. 6 – Mill/Manley Cr. channel migration expansion

Each alternative was evaluated with respect to how well it would be expected to achieve the project goals

and objectives. This resulted in the following ordering (most to least) of how well each alternative achieved this: Alternative 3, Alternative 4, Alternative 6, Alternative 2, Alternative 5, Alternative 1.

4.3. Selection of the Preferred Alternative

The Alternatives Analysis was completed in July 2020 and was distributed to the TOG members for their input (see Attachment 7). A follow-up meeting was held on November 4, 2020 to review and discuss the alternatives and to summarize and review the TOG input. Based on input on the report, discussions at the November 2020 meeting, and multiple follow-up discussions between LCEP and TOG members, further design refinement and analysis was performed. This work was primarily to address suggested edits to Alternative 3 and to further explore a single-thread alternative similar to Alternative 2. Based on this additional analysis, and in consideration of TOG input and the best approach for accomplishing the project objectives, the following suite of actions were selected to move forward to design:

- Modified Alternative 3 – Full pits re-grade with modifications to reduce the number of channels, reduce grading at the upstream end of the reach where the delta has formed, and to better optimize grading to achieve an approximate cut-fill balance on the site.
- Modified Alternative 4/6 – This includes the side channel enhancements of Alternative 4 plus a partial removal of the levee identified in Alternative 6.

Since the original alternatives analysis, additional site analysis, design progress, and funding considerations have further modified the upstream and downstream extents and elements of the project, including creating the new side-channels in the West and East Floodplain areas, pit filling and levee removal at Danger Park, levee and fill removal plus off-channel habitat creation at the County Yard site, floodplain and channel margin work at the Daybreak Trail site, and incorporation of the Dyer Creek area elements.

5. Design Components

5.1. Design Goals, Objectives, and Constraints

Design objectives are included below nested under the corresponding goals. These were developed as part of the alternatives analysis process. More information and additional documentation is provided in the Alternatives Analysis technical memo (Attachment 7). These design objectives have served as design criteria to guide the project. In some cases, there have been minor updates to the original objectives. This primarily included specifying that some of the objectives pertain primarily to the Ridgefield Pits portion of the project area, and may not fully apply to the upstream and downstream portions including the Daybreak Trail and County Yard components.

Goal 1. Restore native vegetation communities

Objectives

- 1a. Promote conditions where channels are well-connected to the floodplain and CMZ and are able to self-initiate and self-maintain riparian vegetation through channel scrolling processes and overbank deposition of fines. Decrease the depth to the alluvial aquifer.
- 1b. Promote a patchwork mosaic of native vegetation communities with a range of age classes consisting of older coniferous forests, cottonwood galleries, willow-dominated shrub communities, and sedges and rushes.

- 1c. Encourage vegetative growth along stream channels, with persistent vegetation abutting the primary channel and side channels that provides hydraulic roughness, natural stability, shade, and habitat complexity.

Goal 2. Enhance thermal refuge and incorporate cold water areas into restoration efforts.

Objectives

- 2a. Protect, enhance, and expand access to existing known cold-water refugia including at tributary confluences, in north-side side-channels, and in select pits (e.g., Pit 9 of the Ridgefield Pits).
- 2b. Achieve a low flow channel width-to-depth ratio that is below 15 and ideally below 12. Increase canopy closure from vegetation to greater than 50%.
- 2d. Increase juvenile salmonid over-summer thermal refugia by creating head gradients that result in strong hyporheic exchange flows – i.e. highly sinuous meanders that create strong gradients across gravel bars where hyporheic flow contributes to backbar alcoves; occasional valley wall contacts with alcoves fed by wall-based channels; and offset riffles around islands.

Goal 3. Increase the quality and quantity of Chinook, chum, steelhead and coho spawning and rearing habitat.

Objectives

- 3a. Achieve a moderate-to-high channel sinuosity (>1.3) to increase planform complexity.
- 3b. Achieve a pool (and riffle) frequency greater than 10 pools per mile in the main channel, co-dominant channels, and active side-channels.
- 3c. Increase large wood quantities to exceed the Fox and Bolton (2007) 75th percentile quantities of wood and key pieces that would be expected under undisturbed conditions. A range of wood size classes should be present, with abundant large pieces exceeding the NOAA 'properly functioning condition' threshold of 80 pieces/mi for wood over 24 inches diameter and 50 feet in length. Wood placements to include individual pieces and jams to provide habitat complexity and to encourage structural formation of bars, pools, and other geomorphic features. Where suitable, jams should recruit mobile wood over time. Wood placements should also occur on floodplains, especially where vegetation is sparse or young, to emulate hydraulic roughness found in natural vegetated floodplains.
- 3d. Increase occurrence of co-dominant and secondary channels (i.e. side-channels) so that 2 to 5 perennial channels (including main channel) occur at any given valley-bottom cross-sections (at least in the main pits reach).
- 3e. Achieve a low-flow channel margin length that is at least five times the corresponding valley-bottom length (at least in main pits reach).
- 3f. Achieve the presence of zero velocity areas during seasonal high flows in order to provide for flood refuge by juvenile salmonids.
- 3g. Create abundant (>8 acres/mile of stream) connected off-channel wetlands and beaver dam complexes that are accessible to fish throughout the year.

Goal 4. Restore Channel Migration Zone and Floodplain Connectivity.

Objectives

- 4a. Expand Channel Migration Zone and floodplain inundation extent by removing (or setting back) levees, riprap, fill, and other hydromodifications impeding channel adjustment or flood inundation to the extent possible given private property and infrastructure constraints.

- 4b. Achieve an active valley width (i.e. extent of intact CMZ and floodplain) that is at least 6 times the active channel width.
- 4c. Achieve overbank flows and significant floodplain inundation that occurs annually for at least 1 month of the year, on average, at least for Ridgefield Pits reach. Five-year flood should create very large inundation.

Goal 5. Create a dynamic channel that allows for natural rates of channel adjustment and sediment transport.

Objectives

- 5a. Achieve slope and channel geometry conditions that are depositional, especially in the Ridgefield Pits segment where net deposition is needed to help build grade lost to gravel mining, but also in other segments that exhibit incision.
- 5b. Achieve bank erosion at meander bends that occurs at a natural rate. Minor erosion may occur every year (<5 feet), with larger adjustments at the 2- to 5-year event (e.g. scrolling) and more dramatic changes (e.g. chute and neck cut-off avulsions) occurring during large floods (>10-year event).
- 5c. Achieve a streambed that is composed of a mix of sediment sizes, with channel bed dominated (>70%) by coarse gravel and cobble and floodplains eventually topped with fine sand and silt. Increase substrate patchiness. Decrease fines to less than 15% in potential spawning areas.

Goal 6. Develop restoration approaches and actions that are consistent with existing land use.

Objectives

- 6a. Do not increase flood damage risk to public or private property or infrastructure unless landowner agreement is obtained.
- 6b. Decrease, or at minimum avoid increase of, potential avulsion of the EFLR into the Daybreak Pits.
- 6c. Design actions that adequately address potential risks to river recreational users.

There are several potential constraints in the project area. These include limitations to the extent of potential channel, floodplain and channel migration zone restoration that can occur at the site. The project area is assumed to be limited by a hard boundary on the river-right side due to the floodplain encroachment starting with the County maintenance yard, then along NE Storedahl Pit Road, the Daybreak Pits processing area, and the downstream-most Daybreak Pit. These constraints limit the ability to restore full channel migration and floodplain inundation to these areas and are not being considered as part of the project area at this time. Another likely constraint to full restoration is the BPA transmission lines and towers at the downstream end of the site and in the river-left floodplain. At the upstream end of the project site, there is bluff erosion on river-left downstream of the Mill Creek confluence. This high bluff erosion is currently threatening a residence, which has already been affected by the erosion. This risk limits the ability to significantly affect channel dynamics in this area. River recreational use is another potential constraint, which could affect the size, location, and configuration of instream log structures. And lastly, the large deficit of coarse riverbed and floodplain material created by the mining of the Ridgefield Pits limits the ability to recover this area to full floodplain connectivity.

5.2. Design Component Descriptions

The project area is comprised of multiple interrelated action areas. These are shown on Figure 1. The restoration actions are described per action area in the sections below. Additional design-level details

are included in the design drawings, technical specifications, and the opinion of probable construction cost, which are provided as separate submittals. The large wood stability evaluation and calculations are included in Attachment 13.

For the Dyer Creek area elements, see the attached Dyer Creek Design Report (Attachment 12) for details of restoration actions, as well as additional background information regarding the investigation and design of the Dyer Creek project actions.

5.2.1. Ridgefield Pits

At the Ridgefield Pits, the design includes re-grading most of the former gravel mining ponds to create a multi-threaded channel network that is well-connected to an extensive floodplain wetland complex. The objectives/design criteria (Section 5.1) provided the guidelines from which design iterations and decisions were made. In order to accomplish objectives 3d, 3e, and 3f, a 3-channel network was developed. This includes one dominant, primary channel with 2 smaller perennial side-channels. The network contains multiple connected alcoves and floodplain wetlands located in former pond areas. In order to accomplish the floodplain connectivity objective (4c), significant portions of the channels in the core pits area are designed to overtop for at least one month per year, for an average year.

A primary feasibility consideration is to achieve an approximate cut-fill balance on the site, in order to avoid the potentially high cost of importing streambed and floodplain material. Because of the past mining activity that removed over 1 million cubic yards of alluvial material, this results in a designed floodplain surface that is lower in elevation than the historical floodplain surface, and lower than the floodplain surfaces upstream and downstream of the site. In addition to achieving an on-site cut-fill balance, this configuration also helps to achieve other objectives and constraints, including well-connected floodplains to support native vegetation (1a), small channel width-to-depth ratios to benefit temperature and shading (2b, 2c), presence of off-channel habitat (3f, 3g), greater channel migration zone and floodplain connectivity (4b, 4c), and maintaining depositional conditions (5a). The lower floodplain surface also allows for creating frequent floodplain inundation within the project area while avoiding an increase in flooding to adjacent areas outside the project area that could present a risk to infrastructure or habitat (6a, 6b).

In order to develop the channel and floodplain grading plan, the existing conditions DTM was modified to create a proposed conditions DTM. The proposed conditions DTM was then used in the hydraulic model to evaluate the effects on inundation extents and hydraulic conditions. This was done via an iterative process of repeat DTM refinement and modeling to optimize proposed conditions.

In addition to the channel and floodplain re-grading, a variety of large wood additions are planned for the channels, alcoves, and floodplain areas. The large wood habitat is designed to primarily accomplish the large wood objective (3c), but will also help support other objectives including pool frequency (3b), high flow refuge (3f), and substrate deposition (5a) and patchiness (5c). Instream wood placements include a variety of wood structure types. These include bar apex log jams at flow splits to support split flow and maintain island vegetation; jams in pools to support pool scour and provide cover; channel-spanning jams in smaller channels or off-channel areas to support sediment deposition and initiate planform changes; general complexity jams to provide juvenile hiding cover and complexity throughout; and floodplain roughness structures that provide hydraulic roughness and high flow refuge habitat throughout the floodplain. Overall, a very high density of in-channel and floodplain wood placements will be necessary to provide hydraulic roughness that will be necessary to support depositional

processes, erosion control, and vegetation growth, especially in the first few years immediately following construction due to exposed soils and young vegetation. Some of the wood for log jams will be generated from on-site clearing activities in areas proposed for grading or access routes. These activities will also provide slash material and smaller woody debris for adding to log structures to enhance complexity.

Planting of native wetland, riparian, and floodplain vegetation will occur throughout the site following construction. This will include a patchwork mosaic of species assemblages selected based on the range of elevations, soil conditions, and inundation frequencies. Three primary planting zones have been identified. These include: 1) an emergent marsh zone, which spans an approximate elevation range between 0 and 2 feet above base flows and will consist of emergent vegetation; 2) a willow scrub zone, which extends from approximately 2 to 5 feet above base flows and includes native riparian shrubs such as willows, red osier dogwood, Douglas spirea, and Pacific ninebark; and 3) a riparian transition zone, which extends above 5 feet above base flows and includes native riparian trees and shrubs such as cottonwood, alder, big leaf maple, Nootka rose, Douglas fir, and western red cedar. Willow trenching, which includes planting rows of willow stakes within linear trenches (3-5 ft depth) of varying lengths, will occur at various locations throughout the site to encourage rapid willow colonization and to provide hydraulic roughness to stabilize soils. These are primarily located in the willow scrub zone but in some cases extend into the other zones where it is believed sufficient depth-to-water and acceptable inundation duration can be achieved.

5.2.2. West Floodplain

The West Floodplain area lies between the Ridgefield Pits and the Dyer Project area. This area is bisected by the BPA transmission lines and has been the site of extensive revegetation efforts by Clark County, Clark Public Utilities, and Washington Department of Ecology. The draft 60% design included a side-channel complex that crossed under the BPA transmission lines, entering the river downstream near RM 7. These side-channels have been removed for the final designs in consideration of cost-benefit, especially related to the need for multiple bridges over the side-channels to maintain BPA transmission line access. However, a new proposed side-channel has been added to the design at “Powerline Bend” at the northern portion of the West Floodplain area. This channel cuts across the bend in the EF Lewis River (“Powerline Bend”) just downstream of the BPA transmission line crossing. The 1,000-ft long side-channel will begin near RM 7.25 and re-enter the East Fork Lewis near RM 7.

This side-channel will provide off-channel rearing and refuge habitat for juvenile salmonids and will increase connectivity with the floodplain. This will help to achieve Goals 3 and 4. The material obtained from the side-channel excavation will be used within the Ridgefield Pits grading. The channel will be activated just above base flows. Large wood habitat will be placed in the channel to help scour pools and provide rearing cover and complexity. Channel banks will be planted with native riparian plantings, mainly consisting of the willow scrub and riparian transition plant communities that are described above in the Ridgefield Pits area description.

5.2.3. East Floodplain

The East Floodplain is located just east of and up-valley from the Ridgefield Pits core area. Restoration actions in the East Floodplain include creation of new side channels, enhancement of an existing side channel, creation of alcoves, creation of floodplain wetlands, floodplain lowering, and levee removals.

These actions will not only enhance habitat and floodplain connectivity in this area but will also provide material to assist with achieving a grading cut-fill balance at the core Ridgefield Pits.

A new side channel network will be created that will originate from near RM 9. These channels leave the mainstem at the large bend where the river splits around an island. Most of the flow is now within the southern channel, which is the avulsion channel that occurred across this bend circa 2007-8. Because the north channel is not active at base flows, these new channels only become active above base flows when there is flow in the north split channel.

One of the new side channels will occupy the abandoned oxbow scar that was the location of the mainstem prior to the 1995 avulsion into the Mile 9 Pit, which was located to the south (current location of mainstem). Floodplain lowering (and assumed development of wetland conditions over time) will occur along the side of this side channel in areas where there is coarse material that will be utilized in the Ridgefield Pits. An alcove will also be created near the downstream end of this channel. This alcove will connect directly to the mainstem, providing high flow refuge and potentially temperature refuge during low flows.

A second, longer side channel will extend from the existing side channel that runs north and flows along Storedahl Pit Road. This side channel re-enters the mainstem just above the Ridgefield Pits reach. Just upstream from the re-entry point, to the south and abutting the mainstem, there will be floodplain lowering (and assumed development of wetland conditions over time) that connects to the mainstem. This will provide habitat and enhanced floodplain connectivity and will also be a source for coarse material for Ridgefield Pits filling. A short connector channel will connect the oxbow side-channel to the new side-channel. Approximately 1,100 feet at the upstream end of the existing Storedahl Pit Road side channel will be enhanced using large wood placements as it is relatively devoid of wood currently.

Large wood will be placed throughout the created side channels, alcoves, and areas of floodplain lowering/wetland creation. Apex log jams will be placed at side channel entrances in order to encourage scour and split flow conditions into side channels. Various log jam types will be placed throughout the side channels. These are generally the same as the log jam types described above for the Ridgefield Pits site. In addition, we anticipate that some riparian trees will be felled into the side channels, mostly alders pushed over by machinery to retain the rootwad. This action provides high complexity habitat of whole trees and can also be used to help facilitate access routes.

There are three push-up levees that will be removed in the East Floodplain. These levees are constructed of coarse river-bed material and are relic features from former flood control and mining operations, and from when the mainstem was in different locations. These features will be removed to enhance floodplain connectivity. They will also provide good coarse material for Ridgefield Pits filling.

5.2.4. Danger Park

Restoration activities in the Danger Park area include gravel pit filling and levee removals. The primary action is the partial filling of the Danger Park pit, which is the north of two former gravel mining pits. The southern pit is already partially filled due to regular inundation and connection to the river. The north pit, however, remains deep and unfilled. There is a ring levee around the north, west, and south sides of the pit that will also be removed. These actions will restore the long-term floodplain and channel migration zone connectivity to this part of the floodplain. Large wood structures will be placed throughout this area for high-flow habitat refugia for fish and to provide hydraulic roughness to limit

flood flow energy in this zone that is adjacent to the Storedahl Pit Road. An additional levee is located to the east of the south County Pit. This levee will also be removed. The Danger Park area is also critical for the project for construction entrance, staging, and access to the remainder of the site.

5.2.5. County Yard

Restoration actions at the County Yard include relocating the County stockpile and sorting yard; removing fill, levees, and armoring; and creating wetland and alcove habitats. The stockpile and sorting yard currently lies well within the channel migration zone of the EF Lewis River. The river has been gradually eroding along its north bank and migrating toward the site at approximately 16 feet per year since 1990. The yard will be relocated to the vacant County-owned property to the east of the current maintenance shop, with access provided from the existing shop/office area as well as a new access point directly to NE 269th Street. In addition, a levee system located generally west and south of the yard will be removed. An alcove and floodplain wetlands will be created within the former yard area. These actions will restore a portion of the channel migration zone to the river and will reconnect the river to the floodplain. The alcove will provide high flow refuge habitat for salmonids. A secondary benefit is the sourcing of fill material that will be used to help achieve a grading cut-fill balance at the Ridgefield Pits. Large wood structures will be placed throughout for habitat and for floodplain hydraulic roughness.

The new County maintenance yard will include various features to provide a similar level of use as the current yard, including a hardened surface, fencing, access routes, and other features.

5.2.6. Daybreak Trail

The Daybreak Trail site consists of a long (approximately 1,500 ft) rapidly eroding streambank that has moved up to an average of 7 feet per year in some locations since 1990. Channel margin habitat is severely impaired and the riparian zone lacks native vegetation. The bank retreat is threatening a paved trail, associated paved viewpoints, and a power pole. Proposed restoration actions include lowering the floodplain adjacent to the channel, bank re-shaping, large wood placed for habitat, and revegetation of streambanks, riparian zones, and floodplain areas.

The existing powerpole will be re-located to just south of the current paved trail as part of a separate effort to be coordinated with Clark County and Clark Public Utilities. The floodplain lowering will occur along the bank and extend south in the form of two lobes/indentations that extend upstream and downstream of the re-located powerpole location. The indentations will extend up to a maximum of approximately 300 feet from the channel at each lobe. Between the lobes, the excavation will extend approximately 50 feet from the channel in order to leave a buffer of high ground between the river bank and the re-located powerpole. The excavation will create two primary ‘benches’ within each lobe, approximately 6-7 feet deep near the channel bank sloping up to 3-4 feet further from the channel, then gradually sloping up to meet existing grades. These excavations will increase floodplain connectivity and flood refuge habitat for fish. The bank margin will be sloped and treated with large wood habitat complexity. Extensive wood placements and planting of native riparian vegetation will occur on the lowered floodplain and all new slopes to provide hydraulic roughness, soil stability, and high flow refugia habitat.

The existing paved trail will be re-located to the south of the lowered floodplain and designed to US Forest Service trail accessibility standards. The existing downstream paved overlook will remain. The

existing upstream overlook will be re-located to just upstream of the excavation area, near the existing top of bank.

5.3. Construction Considerations

Construction feasibility and approach/sequencing have been considered throughout the design process and will be highly affected by the approach taken by the construction contractor. River channel conditions at the time of construction, which are likely to change between now and construction, will also affect construction. Access and staging areas have been indicated on the design drawings; however, the approach taken by the construction contractor and discussions with landowners are likely to affect the specific areas that are used.

An anticipated construction challenge is the re-grading of the Ridgefield Pits reach and the construction of the multi-thread channel system, especially with respect to management of water. Management of water will be necessary to facilitate construction and to limit impacts to meet environmental permit requirements. We anticipate that the re-grading of the site will occur using a multi-part work isolation strategy, where river flow is routed through a portion of the site to facilitate construction of other portions. Based on the current location of the main channel through the pits, the sequence may first involve isolating the mainstem from the adjoining pits. Grading could then occur on either side of the isolated mainstem. Following this, the main flow could be routed into one of the newly constructed secondary channel threads, isolating portions of the main channel from the river for grading. Another re-route in the other channel thread would then likely be required to finish main channel and other grading. The full sequence is likely to require multiple flow bypasses and associated fish rescue. Management of water through cofferdams, pumping, and flow bypasses will likely be required to effectively compact placed fill. We anticipate that full dewatering will not be possible due to subsurface seepage but that pumping will nevertheless be needed to reduce water levels in active construction areas and to manage turbidity. The use of sheet pile, turbidity curtains, and long pumping distances to land-apply construction water may be necessary. An example construction sequence, and other sequencing considerations, are provided in the plans, but it will be up to the selected construction contractor to develop a viable construction strategy that achieves objectives and conforms to permit requirements.

Construction of the East and West Floodplain side-channels will be more straightforward. Most of this work can occur in isolation from the river, leaving soil plugs in place until ready for final connections. Management of water will still likely be required as groundwater will be encountered, especially if the work is performed outside of the driest part of the year. Construction of the County Yard and Danger Park actions can largely occur outside of Ordinary High Water, and so will not be subjected to the timing limitations of the in-water work window. The one exception could be the construction of the alcove at the County Yard site. At Daybreak Trail, the floodplain lowering and wood and vegetation roughness elements on the lowered floodplain can occur in the dry and outside the in-water window. However, bank margin sloping and wood placements will require worksite isolation from the main river, likely requiring temporary cofferdams.

In-water work will need to occur during the permitted in-water construction window. This is listed as August 1 – 15 by WDFW. Because this effort will take considerably longer than 2 weeks, it will be necessary to work closely with WDFW and project designers to develop a sequencing plan that works for the permitting agencies and the project. This will likely entail a worksite isolation strategy that allows for

significant portions of the project re-grading to occur in isolation from the main channel flow outside of the work window period. It is also possible that all of the work for the project will not be able to occur in one construction season, and that the project will need to be phased over multiple years.

5.4. Flood Damage Risk and Public Safety Considerations

In accordance with Goals 6a and 6b (see Section 5.1), the project has been designed in consideration of flood damage risk. Due to the project goals of enhancing floodplain and channel migration zone connectivity, the pattern and profile of flooding will be altered within the project area. These changes increase flood levels in some areas and reduce them in others. For this reason, a FEMA letter of map revision (LOMR) is being pursued for the project. In accordance with FEMA requirements for the LOMR, the project has been designed so that no structures (defined as a “walled and roofed building”) are impacted by an increase in the 100-year flood level. The potential for project actions to affect the flood damage risk to other features has also been evaluated. This evaluation is described in the attached Erosion Risk Memo (Attachment 11). The evaluation used comparisons between existing and proposed hydraulic model outputs, along with consideration of ground cover conditions, to evaluate whether project actions are likely to affect erosion risk in the following areas/features of interest: 1) Daybreak Pits Boundary, which includes the Daybreak Pits, Daybreak Pits processing area, NE Storedahl Road, and Bennett Road; 2) Clark County Public Works maintenance yard; 3) BPA right-of-way (ROW) and towers; and 4) south bluffs from Mill Creek to Bjur Road access. The potential for project actions to affect avulsion risk into the existing Daybreak Pits was also evaluated. The erosion risk evaluation occurred as an iterative process, evaluating risk and then making design changes. The final design actions are expected to either reduce risk to the features of interest or to present no significant changes to risk levels. See the Erosion Risk Memo (Attachment 11) for more information.

Potential impacts of project actions on public safety were considered in the design process in accordance with Objective 6c. The primary public safety concern is the effect on river recreational users (boaters or floaters). For several reasons, recreational use of this section of river is limited. Although nearby portions of the lower East Fork (i.e. from Lewisville Park to Daybreak Park) are included in the American Whitewater river information database, this section is not included as it is not commonly run by whitewater enthusiasts. Due to restrictions on fishing, fishing boat traffic through this section of river is currently low or non-existent. There are also access limitations. Although there is an access point and boat ramp at Daybreak Park just upstream of the project area, the next downstream access point and boat ramp is at La Center Bridge, approximately 7 miles downstream and with considerable slow water in the tidally-influenced section in the last 2-3 miles. Other access points across County land are possible between these two points, but require hiking into or out of the river corridor and are not frequently used. In addition, the presence of large wood and log jams present obstructions and a potential hazard to boating this section of river. This includes mid-channel wood accumulations as well as channel-spanning log jams. The location and configuration of these features are dynamic, changing during high flow events and presenting new conditions each season. The long section of river between access points, low summer flows, slow water, the nearly still water in the Ridgefield Pits, and existing large wood hazards are reasons that recreational boating is limited through the project area.

Despite the limitations described above, recreational floating does occasionally occur and was considered as part of design. Starting upstream, the first constructed log structures are at the Daybreak Trail site. These will be bank-attached structures that extend approximately 10-15 feet into the channel.

There is over 1,000 feet line-of-sight from the straight section upstream. The channel in this section is wide, on the order of ~100 feet or more depending on flow, allowing for avoidance of the structures. There are also gravel bars just upstream and on river-right (opposite bank) for egress from the river.

Below the Daybreak Trail site, near river mile 9, is a split flow section where a large natural log jam has formed on the apex of the bar/island and periodically spans one or both of the channels. The natural hazards provided by wood in this area exceed those that will be provided upstream or downstream as part of the project. The next constructed log structures will be in the core Ridgefield Pits zone, where a new multi-thread channel pattern will be created. There will remain a dominant mainstem channel. Although large wood structures will be placed in this channel, they are all bank-attached structures, with no channel-spanning structures. Due to the lower gradient in this zone compared to upstream and downstream, stream velocities are less. There is also adequate line-of-sight, a wide channel, and gently sloping banks and bars allowing for avoidance and egress.

The next log structures placed as part of the project are at the Dyer Creek riprap banks site, which will have bank-attached jams at both the upper and lower riprap banks. Similar to the Daybreak Trail site, these structures extend into the channel approximately 10-15 feet. There is also good line-of-sight, a wide channel, and multiple gravel bars for easy avoidance or egress. Just upstream of this site is the Powerline Bend site, where there has been placed wood and other bank treatments along the outside of the bend (by others) as well as a naturally-formed apex log jam that was nearly channel-spanning as recently as April 2024. The placed wood at the Dyer Creek riprap bank sites will not present a hazard that is in excess of what currently exists just upstream.

In addition to the precautions and considerations described above, a sign will be placed at the Daybreak Park boat ramp and access point, which is the common access point for people floating this section of river. The sign will explain the project and caution boaters of potential hazards from large wood structures.

5.5. Summary of Ecological Benefits and Ecological Reference

5.5.1. Summary of Ecological Benefits

This project will provide a range of aquatic habitat and river process benefits. The primary benefit will be addressing the currently severely degraded conditions in the Ridgefield Pits reach. This work will immediately improve aquatic habitat and floodplain connectivity at the site and will re-set the geomorphic trajectory to support future channel dynamics, stream temperature improvements, establishment of native vegetation, and continued deposition of streambed material to re-build the channel and floodplain elevations lost due to gravel mining. The Alternatives Analysis (Attachment 7) identified the degree to which alternatives help to achieve the project goals and objectives. Although somewhat modified since the Alternatives Analysis, the design for the core Ridgefield Pits area will have essentially the same ecological benefits as Alternative 3. Of the 23 objectives identified, Alternative 3 is expected to “very much” accomplish 19 of them, “very much” to “somewhat” accomplish 3 of them, and “somewhat” accomplish one of them. The one that it only “somewhat” accomplishes is not an ecological objective but a social one – the consideration of river recreational users. This is because the multi-thread channel and high large wood loading may provide challenges for recreational boaters at some flows.

There are also numerous ecological benefits of the other project components. New and enhanced side-

channels, alcoves, and wetlands will increase habitat availability for salmonids for flood refuge, temperature refuge, and feeding. Removing bank armoring, levees, and fill will increase floodplain connectivity and channel migration processes. Removing and replacing culverts will improve fish passage. Adding large wood will increase salmonid habitat complexity, cover, and hydraulic diversity for flood refuge. Wood will also increase gravel trapping, and will help to create dynamic channel conditions and off-channel connectivity/access for fish. Floodplain lowering at the Daybreak Trail site will enhance floodplain connectivity and allow for newly planted vegetation to thrive. Revegetation throughout the site will have long-term habitat and channel process benefits including providing hydraulic roughness for flood function, natural erosion protection of soils, shading for water temperature benefits, a source for future large wood recruitment, and food/nutrients for fish and other aquatic and terrestrial biota.

5.5.2. Ecological Reference

The ecological reference for the site comes from the historical condition of the site itself. These reference conditions provided important information that was used to inform the design approach and to characterize the overall geomorphic context of the site. However, it's important to acknowledge that many factors are fundamentally changed and the site cannot, and should not be expected to, fully function as it did prior to Euro-American settlement due to those changes.

The oldest mapping information for the site is from cadastral survey plots completed by the General Land Office (now part of BLM) in the 1850s. There are also maps from the early 1900s, aerial photos dating back to the 1930s, WDFW habitat survey report, historical records, and anecdotal information. The following points summarize the condition of the river dating back to the early data sources:

- This section of river supported extensive spawning and rearing for multiple salmonid species including Chinook, steelhead, and coho, with some records indicating it was also important for chum (personal communication with WDFW and Lower Columbia Fish Recovery Board).
- Prior to Euro-American settlement, the Ridgefield Pits reach (including the entire valley bottom in this area) was a depositional zone with an anabranching (multi-thread) channel planform with multiple side-channels and oxbows and an abundant supply of gravels and wood.
- The channel migration zone (CMZ) encompassed both the current day Ridgefield and Daybreak Pits, over a wide floodplain area.
- The large wood in the channel, and large and robust riparian and floodplain vegetation, likely resulted in relative stability of the channel during regularly recurring floods (i.e. annual to 5-year event).
- Channel adjustments, via scrolling and avulsions, likely occurred during the larger, less common events (> Q5 flood event). These events likely created a complex mosaic of highly productive instream and floodplain aquatic habitats.
- High complexity and a highly connected floodplain and water table likely led to a diversity of habitat types and areas of groundwater intrusion that provided cold water inputs.
- Significant changes in land use, including agricultural development and river confinement, were already occurring as early as the 1930s.

6. References

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